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JANUARY 3, 1966

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HE WEEKLY OF ADVANCED TECHNOLOGY

emini 7 Viewed from Maneuvering Gemini 6

PECIAL REPORT—

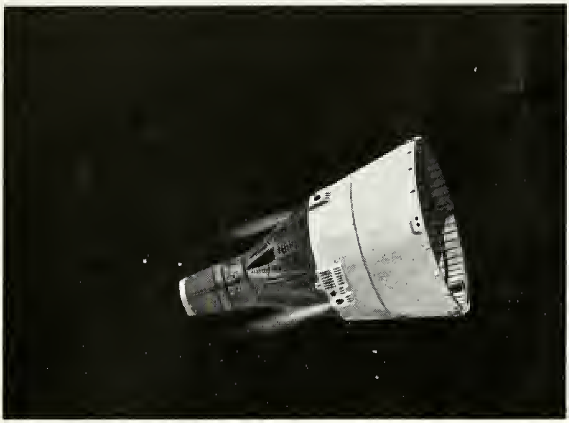
Gemini 7/6 Mission Opens New Era

Army Wins Approval for SAM-D

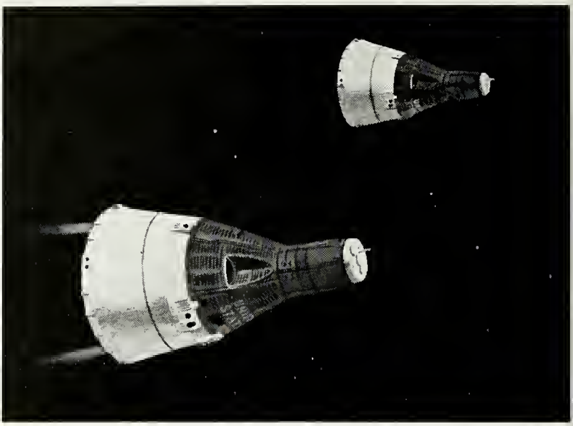
AN AMERICAN AVIATION PUBLICATION

GEMINI RENDEZVOUS

How North American Aviation rocket engines helped U.S. astronauts maneuver in space

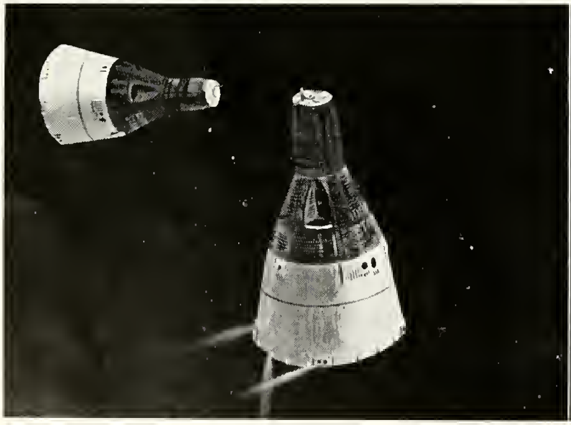


1 Initial height adjustment was made with spacecraft traveling large end first with a boost from two 85-pound-thrust engines. This maneuver placed Gemini 6 in a higher orbit.

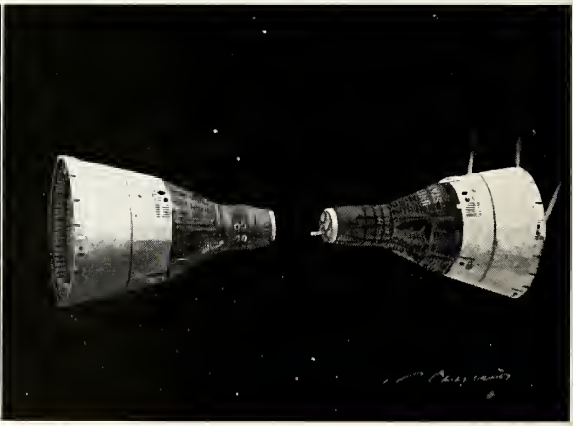


2 Forward boost from two 100-pound engines placed Gemini 6 at its final intersecting orbit with #7. This was after a series of maneuvers that took place during approximately 3½ orbits.

3 During the final stages of the rendezvous, eight 25-pound-thrust engines were used to turn Gemini 6 so both teams of astronauts were facing one another.



4 The historic fly-around maneuver was made possible by 16 individual space engines in each craft, providing the control flexibility required in space flight.



The systems of small rocket engines that maneuvered the NASA Gemini spacecraft were built by North American Aviation/Rocketdyne Division. This division is also the Free World's leading builder of giant liquid rocket engines, and an important producer of solid-fueled rocket engines. NAA engines powered all the Mercury flights and will power Saturn and Apollo space flights. Pioneering new technologies is but one way North American contributes to the nation's growth and security.

North American Aviation

Atomics International, Autonetics, Columbus, Los Angeles, Rocketdyne, Science Center, Space & Information Systems

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 18, Number 1 January 3, 1966

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THE COVER

Striking photograph of Gemini 7 spacecraft taken by Gemini 6 astronauts during maneuvers carried out to bring capsules nose-to-nose. Final closing distance was within one foot. A special report on the completed Gemini 7/6 mission and future program plans starts on p. 16.

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letters

Hogwash Conference

To the Editor:

Your Dec. 6 editorial ("The Hogwash Conference") was a real heartwarmer. Those awful, dreadful, dangerous Pugwash bipeds. And that particularly odious pair Wiesner and Gilpatric. Seems a pity that lavish funds to support such creatures should come from the dedicated sweat of American creativeness and industry. You must have read the Adm. Ward and Schlafly book "Strike from Space."

Barclay K. Read
Sanibel Island, Fla.

Inca's Rocket Sleds

To the Editor:

We compliment Goodyear Aerospace on a fine rocket sled which will be the basis for forthcoming nuclear blast effects programs at the Holloman Air Force Base test track (M/R, Dec. 13, p. 17).

We casually mention that it will be two Inca-designed and -built sleds that will give this payload sled the boost it needs to reach ignition velocity. While most aerospace firms today are concerned with "ups" with "downs," our concern presently is "stops" and "go's."

Inca reverses its roll of "shovers" in early January with an Air Force two-sled program (which we designed and built) that will decelerate for a sustained period of ⅓ second at 150 g's. Sounds like shades of St. Nick!

Peter Price
President
Inca Engineering Corporation
San Gabriel, Calif.

New Space Measurements

To the Editor:

For an earlier and more general proposal for space units, in keeping with the suggestion of Dr. L. A. Geddes (Letters, M/R, Dec. 6), I would refer your readers to "A System of Coordinates for Space," Conference Proceedings, Fifth Annual East Coast Conference on Aeronautical and Navigational Electronics, Oct. 27-28, 1958, pp. 97-102. In this paper, distance and velocity units based upon the velocity of light have been proposed as a more useful and universal system of measurement.

Charles M. Jones
Command Control Division
System Development Corporation
Lexington, Mass.

Truth and the MOL

To the Editor:

I always read with interest your editorials, but this time couldn't let your Nov. 22 item, "Truth and the MOL," pass without throwing a big bouquet of roses your way. It was a fine piece of writing: bold, to the point, and just the sort of thing I would have wanted to say.

Damn it, you're 100% right and, having had the pleasure and displeasure of working with Dept. of Defense security problems for the past five years, I could now and then aim my own rocket smack in the Pentagon "playpen."

Although the Pentagon is aware of it, I don't think most of my colleagues are—that we are the fifth largest weekly magazine in the United States. Although I don't suppose writing for today's teen-agers commands quite the attention that some other publications do, I am particularly chagrined at the idea that DOD and McNamara and Sylvester and Company expect the big lie to begin in the first grade and work up.

Cheers for a really good job!

Lee Hamilton
Science Editor
Junior Scholastic
New York, N.Y.

DASA Launch

To the Editor:

There was an error in your "Shots of the Week" column in the Nov. 29 issue. The modular payload developed for the Defense Atomic Support Agency was launched on an *Honest John-Nike-Nike-Hydac* four-stage rocket, not on the *Nike-Javelin* as reported.

Ronald A. Emerling
DASA Programs Manager
Electro-Optical Systems, Inc.
Pasadena, Calif.

Beyond the Pales

To the Editor:

It was somewhat saddening to read the two letters published in your Dec. 20 Letters column under the heading "Over the Line." Over the line, indeed, and beyond the pale in two directions. While I may not agree with every detail of your Dec. 6 editorial, neither do I consider you to be "paranoids." Nor, on the other hand, do I think "professional appeasers" have taken over.

M. D. Fenton
Houston

Reprints of M/R Index

Reprints of the editorial index of articles appearing in MISSILES AND ROCKETS during the last six months of 1965 are available at no cost from:

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The Countdown

WASHINGTON

MOL Launch Set for Fall

Air Force will launch one of its *Titan III-C* research and development vehicles this fall on a suborbital flight carrying an Air Force version of the *Gemini* capsule to be used with the *Manned Orbiting Laboratory*. Objective will be to test the heat-shield design currently planned for use with *MOL*. That design includes the cutting of a hatch in the heat shield to permit passages of astronauts into the *MOL* canister when the two vehicles are attached.

Hearings May Affect Webb Trip

It is now believed NASA Administrator James Webb will put off his trip to Europe to consult with space experts there on President Johnson's proposal for increased space cooperation until after the NASA FY '67 authorization hearings open on the Hill around Feb. 9 to 15. Arnold Frutkin, director of the office of international cooperation, and Homer E. Newell, director of space sciences and applications, are heading a group drawing up data on future programs for Webb to use in his discussions.

NASA Shows Good Average

The space agency chalked up 23 mission successes out of 28 attempts for an 82% success record in 1965. Its launch vehicles scored a record 26 successes out of 30 attempts for an 87% mark.

Navy Sets ASW Bidder Conference

Navy will sponsor a bidders' conference at the University of Washington in Seattle on Jan. 12-13 for a new anti-submarine warfare target vehicle. Project is said to involve a multimillion-dollar contract for development of a towed underwater ASW target to be in fleet service in about a year.

NASA Adds Re-Entry Shot

NASA is adding a sixth flight to the *Scout* re-entry program. Request for proposal is being issued by Langley Research Center. Bids on the spacecraft are to be submitted by Jan. 25.

NORAD Headquarters Shifted to Hard Site

Headquarters of the North American Air Defense Command was shifted to the nuclear-hardened complex built into the side of Cheyenne Mountain, Colo., on Jan. 1 (M/R, Feb. 24, 1964, p. 40). The NORAD facility, however, will continue to operate in conjunction with the present above-ground site at Ent AFB in Colorado Springs for the next few months, until the hard site is declared fully operational.

NASA Asks Gemini 6/7 Record Okay

NASA is applying to the Fédération Aéronautique Internationale for certification of the *Gemini 6/7* flight as the record for the longest formation flight in space. The mark is 20 hrs. 22 min. within 100 mi. of each other. FAI recognition is expected in about four months.

LEM Tanks Are a Headache

NASA still is having trouble with titanium tanks of the Lunar Excursion Module. They have been cracking open consistently when the nitrogen tetroxide cryogenic fuel is used. One plan to solve the problem calls for thickening of the tank walls and another for coating the inside with Teflon. NASA officials say they are not seriously worried about the difficulty.

INDUSTRY

Defense Electronics Business Zooms

A top West Coast electronics executive, Litton Vice President John S. McCullough, estimates that business in the defense electronics sector was up about 30% in 1965, largely as a result of the war in Vietnam. McCullough says that heaviest growth appears in the components areas, particularly in expendable items and in microwave tubes.

Cunningham To Manage Mariner

William B. Cunningham, formerly director of the *Ranger* program at NASA headquarters, has been named to head the *Mariner* 1969 spacecraft program. Glenn Reibb, current head of the *Mariner* program, will manage the effort to explore Venus with another *Mariner* spacecraft in 1967.

Aerojet Realigns Sacramento Management

A realignment of management at the Sacramento plant of Aerojet-General Corp. has resulted in establishment of an executive committee to serve as senior management group. The committee is chaired by Robert B. Young, corporate vice president and plant general manager. The moves reflect a continuing trend toward consolidation of the plant's liquid and solid rocket operations.

GCA Selected for AA Experiments

GCA Technology div. of the GCA Corp. has been selected by NASA to propose significant and feasible meteorological experiments which can be performed in the *Apollo* Applications program. Experiments for Project *Apollo* and a manned space station program also will be considered.

INTERNATIONAL

Japan Considers Planetary Probes

Japan is studying the possibility of launching 60-lb. probes to Mars and Venus after the 1968 orbiting of that nation's first satellite. According to a leading Japanese rocket engineer, Dr. Hideo Itokawa, the *Mu* series vehicle, to be used for the satellite launch, is capable of the interplanetary missions. The vehicle, which will have a thrust of more than 400,000 lbs., is under development by University of Tokyo's Institute of Space and Aeronautical Science.

Farnborough Gets New Look

Britain's Farnborough Air Show will have a new look this year. In what is described as "a first step" in broadening the scope of the display, foreign aircraft with British engines and a percentage of British-designed equipment may be nominated for the show. Foreign-designed equipment scheduled for manufacture in Britain under license also will be eligible. Farnborough, scheduled for Sept. 5-11, hereafter will be held every two years, alternating with the Paris Salon.

The Missile/Space Week

DOD Lists Top RDT&E Firms

The top 500 military research, development, test, and evaluation contractors for Fiscal Year 1965 received $4.7 billion in Defense Dept. business, according to a Pentagon report. The list includes 130 educational institutions, government agencies, or other non-profit organizations, in addition to three foreign contractors.

Of the 367 business firms on the list, 121 are designated small businesses. Ninty-five firms that appear on this year's list did not appear last year.

Leading the list is General Dynamics Corp. with $446 million. Rounding out the top 10 are: Western Electric Co.—$354 million; Lockheed Aircraft Corp.—$259 million; North American Aviation, Inc.—$245 million; General Electric Co.—$236 million; Martin Marietta Corp.—$215 million; Ling-Temco-Vought, Inc.—$147 million; Hughes Aircraft Co.—$144 million; Pan American World Airways, Inc.—$122 million; and Massachusetts Institute of Technology—$119 million.

Pioneer Gathering Solar Data

NASA reports that the *Pioneer 6* spacecraft is operating successfully as it begins its first trip around the Sun.

Project scientists say an early look at *Pioneer's* data indicates the solar wind is blowing at relatively slow speeds, magnetic fields are fairly unfluctuating, and that comparatively few charged particles are being encountered.

Scientists at NASA's Ames Research Center say early data show, for instance, that the solar wind velocity is about 670,000 mph compared with velocities of two million mph that have been registered in periods of high solar activity.

Pioneer 6 completed the initial phase of its mission at 10:57 p.m. EST, Dec. 17, when it achieved final Earth-Sun orientation some 230,000 miles from Earth. It acted on 175 Earth commands to focus its high-gain, narrow-beam antenna on Earth.

Sun orientation assured a good supply of electric power and the focusing of the high-gain antenna on Earth increased the strength of the spacecraft's eight-watt radio signal by some 10 times. This is required for *Pioneer* to communicate with Earth after it passes beyond about 10 million miles from Earth.

Pioneer 6 was launched into its interplanetary trajectory between the orbits of Earth and Venus at 2:31 a.m. EST, Dec. 16, from Cape Kennedy, Fla. The launch vehicle was the *Thrust-Augmented Improved Delta*—the 35th *Delta* launch, but the first on an interplanetary mission.

Aluminum Hemispheres for Deep Sea Work

These huge aluminum hemispheres (Alcoa high-strength 7079 alloy) are designed for a variety of operations at extreme ocean depths. They will be machined to desired dimensions and used either singly as structural components in underwater vehicles or joined together to form spheres that can support heavy equipment or house delicate electronic instruments. Among the largest aluminum forgings ever made, they were produced by Alcoa's Cleveland Works. Each section is 8 ft. in diameter and weighs 12,000 lbs. They were forged on a 50,000-lb. press operated for the Air Force.

NATO Spending Rises

NATO defense spending in 1965 rose $1.6 billion above 1964 levels, according to a communique issued late last month by the NATO council.

Total last year was $74.24 billion, up from $72.6 billion in 1964. Total spending by the European members increased from $19.7 billion to $20.6 billion, while U.S./Canadian spending jumped from $52.9 billion to $53.6 billion.

LTV Gets Michoud Task

The space agency has selected the Range Systems Div., Dallas, of Ling-Temco-Vought for final contract negotiations to provide computer support services for the Michoud Assembly Facility at New Orleans.

A cost-plus-award-fee contract will be negotiated for a one-year period with provisions for three consecutive one-year renewals. Cost for the first year is expected to exceed $1.5 million.

MSFC To Use 'Super Guppy'

Marshall Space Flight Center has awarded a one-year contract to Aero Spacelines, Inc., Santa Barbara, Calif., for flying large rocket cargoes in its "Super Guppy" aircraft.

The plane is the only aircraft in existence that can fulfill the size and weight requirement for such outsized cargoes as the S-IVB stage of of the *Saturn* vehicle, the *Saturn IB* and *Saturn V* instrument units, and the Lunar Excursion Module adapter.

The contract, for an estimated $1.6 million, will run through Nov. 30, 1966, and provide for three one-year renewal options. The agreement also provides for an extension of a previous NASA-Aero Spacelines contract for the use of the firm's smaller "Pregnant Guppy" craft.

Missile Sales Down for '65

Aerospace Industries Association, in its year-end summary, reports that sales by the industry to the Defense Dept. declined by 10.6% in 1965 in comparison to 1964 levels. In dollar value this translates to $11.8 billion in 1965 from $13.2 billion in 1964. Overall procurement dipped by $0.9 billion while R&D declined by $0.5 billion.

Biggest decline was in the missile field, where procurement dropped from $3.1 billion to $2.0 billion and missile RDT&E from $2.1 billion to $1.7 billion.

Total industry sales, including DOD, NASA, and commercial activity, according to AIA, netted the industry its biggest year in 1965.

Total sales for 1965 were pegged at $20.9 billion, up from $20.7 billion in 1964. Commercial aerospace sales were up an amazing 39.2%. Net profit after taxes as a percent of sales, the report states, was 3.1%, up from 2.6% last year. This figure however, stil trails the 5.5% recorded as a total for all manufacturing concerns.

Estimated industry backlog now stands at $18.6 billion, compared to $15.4 billion at this time last year. Aerospace exports were also up 15.5%, equivalent to $1.4 billion.

The AIA capped its report by predicting total sales in 1966 reaching $22 billion.

Saudi Hawk Buy Confirmed

Raytheon Co. late last month announced receipt of a letter of intent from Saudi Arabia for purchase of more than $100 million worth of *Hawk* surface-to-air missiles and associated equipment (M/R, Dec. 20, p. 9). The *Hawk* is to be part of a new Saudi air defense package that also includes British-built Lightning interceptors and a new ground environment control system.

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Shots of the Week

The Soviet Union has launched four more satellites in its unmanned *Cosmos* series—*Cosmos 100* through *103*. *Cosmos 100* was sent aloft Dec. 17, *Cosmos 101* Dec. 21, and *Cosmos 102* and *103* on Dec. 28.

● The U.S. was also active in secret satellite launches, firing two from Vandenberg AFB, Calif. The first was launched Dec. 22 aboard a *Scout* vehicle. The other went up aboard a *Thor-Agena* Dec. 24. No details were announced.

● The third launch of the Air Force *Titan III-C* took place Dec. 21 from Cape Kennedy. It was termed a partial success. (See story, p. 14.)

● A *Thrust-Augmented Improved Delta* successfully orbited NASA's *Pioneer 6* solar spacecraft Dec. 16 from Cape Kennedy. (See story, p. 8).

● An Air Force Strategic Air Command crew launched a *Titan II* ICBM from Vandenberg AFB Dec. 22.

● The Navy scored its 23rd straight success with the *Polaris A-3* in a launch Dec. 20 from the SSBN Benjamin Franklin submerged 30 mi. off the Florida coast. The missile sent a dummy warhead more than 1,500 mi. down the Eastern Test Range.

● A *Nike-Apache* sounding rocket launched by Brazil from the Natal range Dec. 18 reached an altitude of 117 mi. It was the second Brazilian sounding rocket launch in a meteorological program.

Two To Produce Torpedo

Navy has chosen to have its new Mod. 1 Mk 46 torpedo (M/R, Dec. 6, p. 9) produced by two sources.

Aerojet-General has won the bulk of the production award with a $65 million contract. Honeywell will also produce the weapon under a $42.5 million contract. The new liquid propellant powerplant for the torpedo will be supplied by the government.

Seamans Sworn in at NASA

Dr. Robert C. Seamans, Jr., was sworn in Dec. 21 as Deputy Administrator of the space agency.

The 47-year-old NASA Associate Administrator succeeds Dr. Hugh L. Dryden, who died Dec. 2. Dr. Seamans also will retain his present position as Associate Administrator for an indefinite period.

King Joins Space Agency

R. E. King, former manager of labor relations at the Convair Division of General Dynamics Corp., San Diego, Calif., will join NASA Jan. 5 as director of labor relations.

King, who will be based at NASA Headquarters in Washington, will serve as NASA's chief executive for all labor relations matters involving contractors and unions on NASA projects.

NASA Sets ADP Briefings

NASA has decided to hold an annual briefing to inform the automatic data processing industry of the agency's future plans and policies for the procurement of large-scale computing systems.

The annual briefing is part of the agency's three-point plan to keep the industry better informed as to its future requirements.

The other two parts of the plan:

—Individual computer manufacturers will be given an opportunity to conduct annual briefings for NASA's ADP personnel to inform NASA of their plans, problems and developments.

—In connection with large or unusual ADP procurements with restrictive requirements, NASA plans to hold pre-specification briefings for interested companies in advance of issuing requests for proposals.

Edmund C. Buckley, Director of the Office of Tracking and Data Acquisition, told a Dec. 22 briefing that the agency's future ADP procurements will be for computing systems rather than just hardware.

In an afternoon session NASA Director of Procurement George J. Vecchietti introduced Paul F. Fuhrmeister of NASA's Langley Research Center, Hampton, Va., and Charles Bradshaw of Marshall Space Flight Center, Huntsville, Ala., who outlined current computer equipment procurements pending at their centers.

The Langley request for proposals is for an integrated computing facility for handling Langley applications in analytical and engineering studies, experimental research, data reduction and simulations conducted in real time.

The Marshall request for proposals is for computation equipment (hardware and software) that will make up the "third-generation" computer system to replace the existing computer systems at Marshall, and at Slidell, La.

The 14 computer firms represented:

Control Data Corp., Burroughs Corp., Computer Control Co., Digital Equipment Co., General Electric Co., Honeywell, Inc., International Business Machines Corp., National Cash Register, Philco Corp., Radio Corporation of America, Raytheon Co., Schlumberger Ltd., Scientific Data Systems and Sperry Rand Corp.

Missile Ship Trials Begin

The Navy has begun sea trials with the first of a new class of guided missile escort vessels, the USS Brooke (DEG-1).

The ships, three of which will be built by Lockheed Shipbuilding and Construction Co. of Seattle, carry *Tartar* surface-to-air missiles. The other two ships are also expected to be delivered later this year.

The vessels are also armed with the *Asroc* ASW weapons, the DASH drone helicopter, guns, and eight ASW torpedo tubes.

NASA Promotes Moritz

Bernard Moritz, Assistant General Counsel for Procurement, has been named Assistant Deputy Associate Administrator for Industry Affairs at NASA Headquarters.

S. Neil Hosenball, chief counsel at NASA's Lewis Research Center, Cleveland, will succeed Moritz in the headquarters legal post.

In his new job, Moritz will assist William Rieke in directing NASA's Office of Industry Affairs. This Office handles the space agency's activities in procurement matters, reliability and quality assurance, facilities management, labor relations and NASA's Western Operations Office.

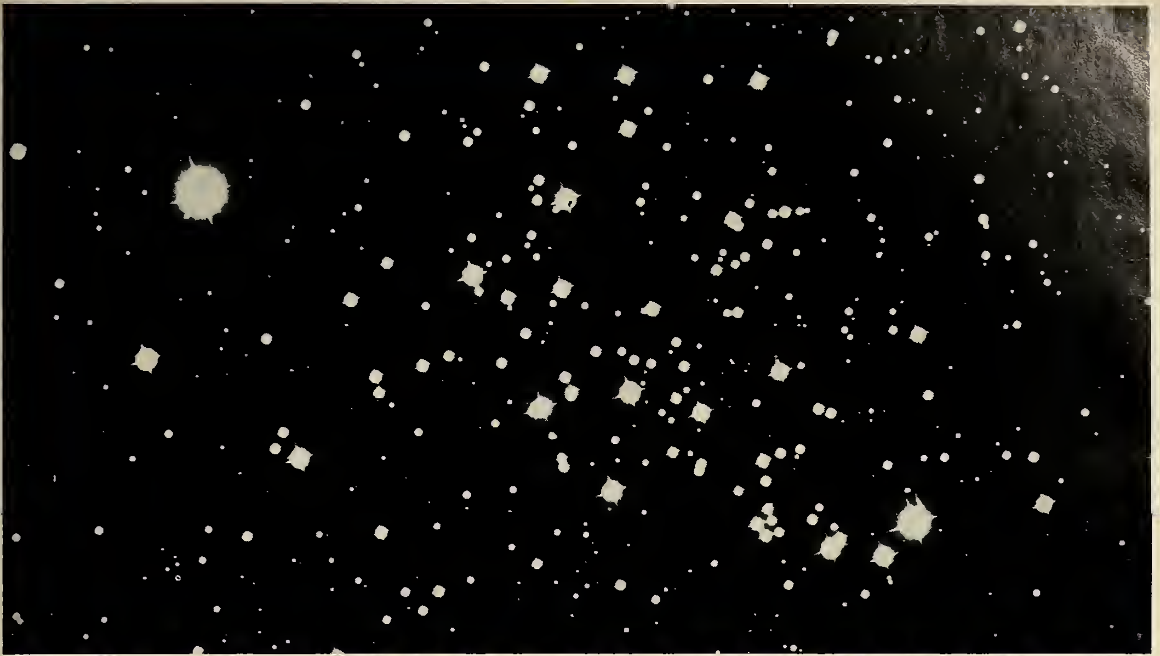
White, Sweeney Die

Two former top Air Force Generals, Thomas Dresser White and Walter C. Sweeney, died within days of each other late last month.

Gen. White a former Air Force Chief of Staff, was one of the leading planners and advocates of the strategic arm of the service, while Gen. Sweeney, a former commander of the Tactical Air Command, proved to be an equally powerful force in the Air Force's buildup of tactical air power.

White retired from the Air Force in 1961 after more than 40 years of service. He held key positions in all parts of the world and became fluent in seven languages. His promotion to four-star rank came in 1953, and he eventually succeeded Gen. Nathan Twining as Chief of Staff.

Gen. Sweeney spent much of his 35 years service in SAC, but was named to command TAC during the Berlin crisis of 1961. Prior to his retirement in July, 1965, Gen. Sweeney was also responsible for directing the buildup of tactical air force strength in Vietnam.



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Army To Begin SAM-D Contract Definition Phase

by Michael Getler

THE ARMY has received Department of Defense approval to move into the contract definition phase (CDP) for its long-sought-after *SAM-D* air missile defense system.

Requests for proposals from industry are expected to be issued by the Army Missile Command project office in Huntsville, Ala., early this month. Although both Hughes Aircraft Co. and RCA have had continuing Army support for component R&D for *SAM-D* (M/R, Oct. 25, p. 9), several firms in addition to these two will be asked to submit proposals for the new missile system. The bidding will be limited, however, to what the Army calls "firms which have demonstrated missile R&D capability."

Current Army plans call for submission of the RFP under phase A of contract definition within 60 to 90 days, with selection of one or more contractors to move into the next portion of the contract definition phase in March. The Army will use Fiscal Year 1966 funds for the CDP.

Phase B of the CDP will run 4-5 months, after which the Army will decide whether or not an additional definition period is required or whether a contractor can at that time be selected to proceed with full-scale engineering development.

Development aims—Army spokesmen say they hope to move into the engineering development phase in FY '67. The operational date set for fielding these weapons is highly dependent upon when this development phase is started. Should this phase begin in FY '67, the Army believes it could start putting the *SAM-D* into the field in 4-5 years.

Should *SAM-D* proceed successfully through its early phases and move, with DOD approval, into production, Army sources say the "eventual magnitude of the program will be tremendous, possibly in excess of $2 billion."

The new missile is intended to replace both the currently used *Hawk* and *Nike-Hercules* surface-to-air missiles in their respective roles with the field Army, and as fixed-site continental air defense missiles. Both of the programs it will replace have grown in value to more than $1 billion each.

SAM-D will be developed essentially as a single weapons system. The field Army version is designed to provide protection primarily against high-performance aircraft operating down to very low altitudes, but will also include "whatever anti-missile capability we can get," the Army reports.

The system is designed for considerable battlefield mobility. It will be mounted on several vehicles rather than attempting to place it all on a single vehicle as was the case with the Army's ill-fated *Mauler* air defense system.

All-new system—The components will include a phased-array radar, a mobile multiple-missile launcher mounted on a separate vehicle, and probably one or two other vehicles mounting associated support equipment. The missile is described as a totally new weapon, not an upgrading of existing air defense systems.

In the continental defense version, the same radar, missiles, and components as the field system will be used, with system design intended to allow the vehicle-mounted units to be set up at a semi-fixed installation.

Initiation of *SAM-D* contractual definition had been held up pending completion of a series of DOD-ordered commonality studies relating *SAM-D* to the Navy's *Advanced Surface Missile System* (*ASMS*), the fleet air defense system projected for the 1970's.

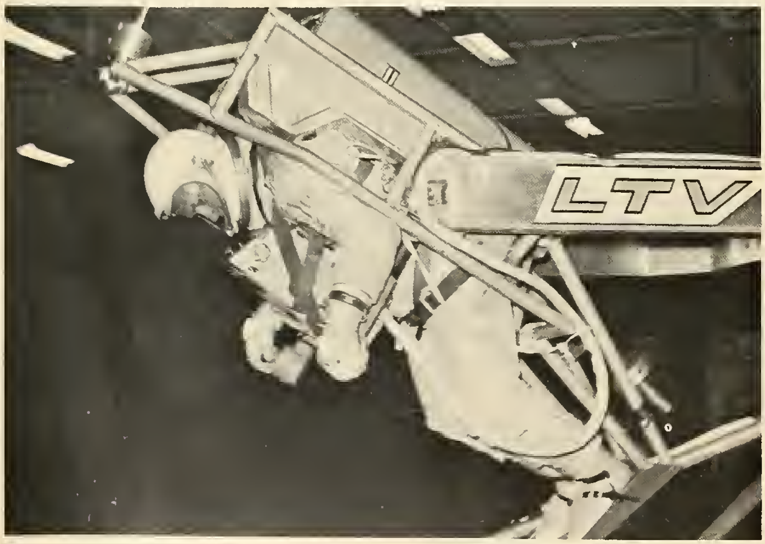
Although these studies reportedly showed that it was not now feasible to proceed concurrently with joint development of the two weapons, the future of *ASMS* is still intimately linked with *SAM-D* in both technological and management lines.

Navy interest—The RFP to be issued by the Army this month will include Navy inputs calling attention to those areas in which commonality with Navy needs is deemed possible and will also include Navy specifications and environmental operating conditions for those systems. The inclusion of the Navy data is expected to provide industry with an option to propose on several alternate development plans if it so chooses.

From this exercise, the Navy hopes to accumulate sufficient cost and technological information to enable it to move into contract definition on *ASMS* at the conclusion of the Army CDP.

The Navy participation in the *SAM-D* effort is expected to last at least through the Army CDP, and possibly beyond that, depending on the extent to which industry and Army evaluations indicate common development can be undertaken.

Project officers stress, however, that the principal immediate requirement behind the entire program is to come up with a missile system that meets the Army's needs, and to do so with whatever commonality with the Navy can be achieved. ■



Astronaut Maneuvering Unit Tested

James B. Griffin, LTV Aerospace Corp., begins somersault in test of astronaut maneuvering unit developed by firm's Astronautics Div. for Air Force. The AMU is scheduled for advanced extravehicular activity during Gemini 9 flight this year.

Priority Funding for Apollo, Mariner

New NASA budget expected to enable Applications program to initiate hardware this year; two new Mariners planned

by Hal Taylor

THE *APOLLO* Applications program and two new *Mariner* spacecraft flights to Mars in 1969 are apparently the only two new major space programs that will receive substantial funding in NASA's Fiscal Year 1967 budget.

Space agency officials report that the RFP for systems definition of *Apollo* Applications will be issued by the Marshall Space Flight Center early this month. It will call for a six-to-nine-month definition study by at least two firms working on parallel contracts. Hardware development would then be initiated before the end of the year.

At the same time, NASA said that Jet Propulsion Laboratory will manage development of the two new 800-lb. *Mariner* spacecraft. JPL will serve as prime contractor for the spacecraft, but it plans to increase the role and number of subcontractors in their development.

Together with a planned flight to Venus in 1967 with an existing 500-lb. *Mariner*, the two new missions are expected to cost a total of $160 million over four and one half years.

While no final decision on the space agency budget has been made, it apparently will range from below $5.1 to $5.2 billion when President Johnson wields his final budget-cutting axe. This compares to the agency's requested $5.6-billion budget.

Voyager, Surveyor suffer—The tightness of next year's budget already has forced NASA to delay the first *Voyager* spacecraft mission to Mars until 1973, two years beyond the originally planned 1971 target date.

Officials reported that Fiscal '67 funding for *Voyager* will range in the $15-30-million range. Although three firms are currently completing preliminary systems definition studies, NASA officials report that hardware development of the spacecraft will be delayed for 1½ to 2 years.

At the same time, NASA is also reducing the number of spacecraft in its *Surveyor* project. Instead of four engineering spacecraft and three operational vehicles, NASA has now decided to build a total of seven engineering spacecraft—which can do little more than take TV pictures of the lunar surface after the soft landing—and only three so-called heavy, 2,500-lb. spacecraft.

The agency hopes to complete launching of the seven engineering models by the end of 1967, in an effort to provide significant data for Project *Apollo*. There have been published reports that NASA is considering cancellation of the three operational spacecraft for budgetary reasons, but this has been denied by Dr. Homer E. Newell, associate administrator for space sciences and applications.

Funding for the *Apollo* Applications spacecraft and its experimental payloads is expected to top $100 million but be well below $200 million in the next fiscal year. Funding for spacecraft next year will be almost entirely restricted to those vehicles which may be available as excess spacecraft when Project *Apollo* is completed.

Unmanned plans—The unmanned exploration program for Venus and Mars now calls for a total of three launches before the end of this decade.

In 1967, the flight spacecraft which backed up the highly successful *Mariner IV* mission to Mars in 1965 will be modified for launch to Venus in mid-year. The spacecraft will be launched by an *Atlas-Agena* and will take three to four months to reach the planet. The scientific experiments will be improved versions of those flown on previous *Mariners*. The spacecraft will also be aimed to fly closer to Venus than the 21,600-mi. approach to the planet made by *Mariner II* in 1962 after a 109-day journey.

In 1969, two 800-lb. spacecraft—based heavily on the technology of previous *Mariners*—will be developed for fly-by missions to Mars. The launch vehicles will be *Atlas-Centaurs*. There has been no determination as to what scientific instruments will be carried.

Agency officials said that while Jet Propulsion Laboratory will serve as prime contractor and be responsible for assembling and testing the spacecraft, plans call for extending subcontractor participation to a greater extent than in the development of previous *Mariner* spacecraft.

In 1973, two heavy *Voyager* spacecraft will be launched to Mars. Both spacecraft will orbit the planet as well as land large capsules on the Martian surface.

While NASA expects to delay hardware development of the spacecraft for 1½ to 2 years, it plans to continue study of the capsule with preliminary systems definition work to begin late in 1966 or early in 1967.

That schedule will delay hardware development until late 1967 or early 1968.

Karth on Surveyor—The changes in the *Surveyor* program were revealed in a report by Rep. Joseph Karth (D.-Minn.) following his recent trip to California to inspect U.S. unmanned spacecraft projects.

He said that while the seven engineering spacecraft will carry only a single panoramic TV camera along with a touchdown dynamics experiment, "successful missions of even this stripped-down spacecraft are expected to provide valuable information in support of the United States manned lunar project."

In addition to the switch to seven engineering models, the three operational spacecraft may also be changed. He said that the approach TV will probably be deleted and an *Apollo* landing aid added. The aid is a balloon-like device which will be inflated in a fashion similar to that used with the *Echo* passive communications satellite. If the experiment is added, it will require that the micrometeorite detector and surface sampler experiments be removed.

One particular problem continues to threaten to seriously cut down the amount of data which may be returned by a *Surveyor* even if it soft-lands on the Moon successfully. Robert Parks, *Surveyor* project manager at JPL, told Karth that the signal that is expected to transmit information from the touchdown dynamics experiment may be lost at the moment of impact. This will be caused by the noise and vibration of impacting on the Moon, which could interfere with the relatively weak signal. The expected availability of the new 210-ft.-dia. dish at the Goldstone, Calif., tracking station will probably help alleviate the problem.

Also being considered are small engineering changes to insulate critical electronic components from the shock of impact.

The first of three engineering test vehicles to be launched this year will not fly until May. ■

Control System Caused Titan Failure

Air Force believes attitude control malfunction forced Transtage to tumble prior to final burn; IDSCP may face delay

AIR FORCE ENGINEERS analyzing data from the Dec. 21 flight from Cape Kennedy of a *Titan III-C,* during which the Transtage upper stage failed to ignite for its final burn, now believe the failure was caused by a malfunction of the *Titan's* attitude control system.

First indication of trouble with the system came shortly after the first of three scheduled Transtage burns. Just prior to the stage's second burn, technicians dubbed the system's performance as "marginal."

It is now believed with some certainty that after the successful second burn of the Transtage, but before the scheduled third burn, the attitude control system failed, causing the stage to tumble. The tumbling action, it is felt, disabled the vehicle's inertial guidance system sufficiently so that it never commanded the stage to ignite for the third time.

The result was that the Transtage and its four-satellite payload were placed in a highly elliptical orbit ranging from 105 to 18,174 n. mi. The flight plan had called for the Transtage—whose first burn circularized the vehicle in a 91-n. mi. Earth-orbit, and whose second burn sent it into the transfer maneuver to the higher altitude—to burn for a third time in order to circularize the orbit at 18,200 n. mi. while also changing the orbital plane from a 26-deg inclination to an equatorial position.

Despite the malfunction, three of the four satellites were ejected and are operating, albeit in the wrong orbit. At this point, AF spokesmen believe the ejection occurred because of a false indication to the guidance system that the third ignition had taken place. They speculate that this may have been due to the additional acceleration increment caused by the tumbling.

Actual cause of the attitude control system malfunction has not yet been determined; however, AF engineers were expected to have completed analysis of telemetry data from the flight by late last week.

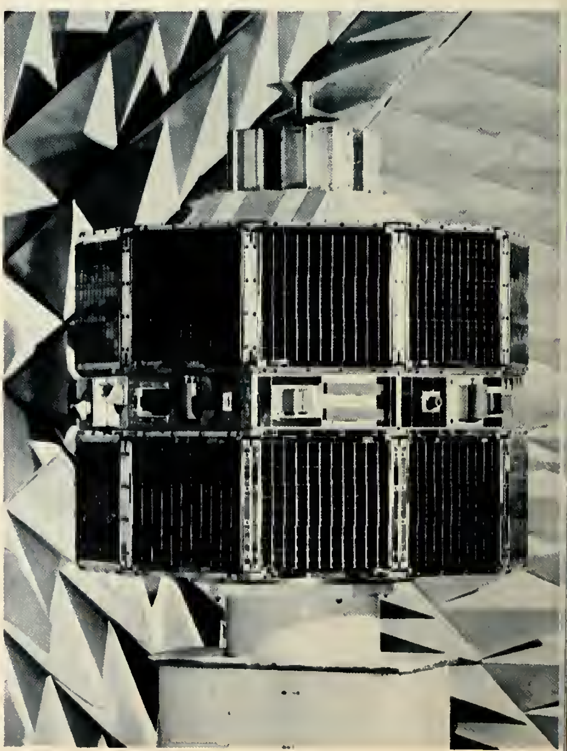
Prime contractor for the attitude control system is the Martin Co., with the Rocketdyne Div. of North American Aviation, Inc. holding a subcontract for the attitude motors.

Military comsats threatened—Paying closest attention to what the Air Force has to say will be officials of the Initial Defense Satellite Communications Program (IDSCP). Each of the next three *Titan III-C* launchings is currently scheduled to place eight 100-lb. military communications satellites into near-synchronous altitude equatorial orbit.

The flight Dec. 21 was a dress rehearsal for the upcoming IDSCP missions (M/R, Dec. 20, p. 18), involving the same flight plan and similar payload weights. The in-flight failure marred an otherwise perfect countdown and launch of the 2.4-million-lb.-thrust booster.

The failure to complete the mission was the second consecutive failure for *Titan III-C.* During the previous flight, on Oct. 15, the Transtage also began to

LEFT: Dec. 21 launch of Titan III-C from Cape Kennedy begins perfectly after flawless countdown. Flight was total success through second burn of Transtage. RIGHT: LES-4, one of pair of Lincoln Laboratory Experimental Satellites that were orbited successfully, along with OSCAR amateur radio relay satellite. Shown in test chamber, unit is undergoing measurement of beam patterns of multipurpose antenna structure mounted atop satellite. (Pyramids are made of material that absorbs radio waves and cuts down reflections from walls of chamber.) Two rings of square panels are covered with solar cells to generate power.



tumble during its second burn and eventually broke up in orbit (M/R, Nov. 8, p. 10).

Members of the IDSCP project told Missiles and Rockets that, with the AF data hopefully in hand, a meeting would be held this week to determine the IDSCP schedule. If analysis shows that the failure was an isolated event not apt to happen again, there probably will be no change in the plans to launch the next *Titan III-C* with its eight IDSCP satellites aboard next spring.

However, planners also report there is a strong possibility that the first IDSCP launch will be delayed, and that another *Titan III-C* test mission, following the same flight plan, will be flown to demonstrate correct performance on the transfer maneuver prior to launch of the actual military comsat hardware.

Should a major flaw be found somewhere in the *Titan III-C* system sufficient to make its use not likely for IDSCP, mission planners say the satellites could be launched into a lower orbit, of approximately 6,000 n. mi., using an *Atlas-Agena* launch vehicle. This possibility is now considered most remote by IDSCP officers.

LES dividend—Biggest bonus to be salvaged from the flight appears to be the ability of the two *Lincoln Laboratory Experimental Satellites (LES-3* and *-4)* to complete many of their mission objectives.

Laboratory spokesmen told M/R that UHF beacon signals being received from *LES-3* will enable study of UHF propagation from satellite altitude.

Initially low voltages on *LES-4* (probably caused by the incorrect orbital position, which displaced the spin axis, and hence the solar cells, from the intended position) have been increased with time in orbit and vocoded voice communications have been carried out with the new Lincoln Experimental Terminal in Massachusetts. Indications are that the new electronically-despun horn antenna array is also functioning satisfactorily, though signals are weak, also due to incorrect orbital position and spin-axis alignment.

The *OSCAR* amateur radio relay satellite, the other package to be successfully ejected, appears to be functioning well, to the immense satisfaction of ham radio operators around the globe.

ITL qualifies—The launch was the first in which the new Air Force Integrate-Transfer-Launch (ITL) complex had been fully utilized. Previous *Titan III-C* shots had gone from nearby pad 40, after having been assembled and/or tested on that pad, but the third vehicle was fully assembled and checked out before it was moved to Pad 41 for launching. It was also the first launch from the new pad itself. Hence, ITL is now considered operational. ■

NASA Budget To Be Squeezed By Boost in DOD Spending

by Heather M. David

CONGRESSIONAL OBSERVERS are forecasting some rough going for NASA in the annual budget round that will begin about Jan. 24 with submission of the Administration's request for Fiscal Year 1967 funds.

The size of the Defense Dept. budget, expected to be from $57 to $60 billion—in addition to a $5- to $7.5-billion FY '66 supplemental request for FY '66 funds to be made as soon as Congress convenes Jan. 10—will result in pressure from many quarters to reduce federal spending in other areas.

NASA support continues to be strong in the House and Senate Space Committees, but the challenge probably will come when the authorization bill first is brought to the floors of the two chambers, and again during appropriations committee actions.

Another House group not directly connected with the budget process has already announced its intention to look into the question of whether the lunar landing program could be postponed until 1975. This group, a new subcommittee of the House Government Operations Committee, is headed by Rep. Henry S. Reuss (D.-Wis.). Hearings on the entire federal research and development program and its relation to national goals will be called in January.

Early attention—The House Space Committee, which traditionally is first to take up the NASA budget, will begin hearings almost immediately when the budget is submitted, Chairman George P. Miller (D-Calif.) told Missiles and Rockets.

In addition to continuing programs, House Space Committee subcommittees will particularly be looking at project *Voyager*, with an eye to whether there is an alternative way to get some of the information the program is aimed at providing earlier than is now envisioned, with a better yield for the entire *Voyager* program.

The *Nimbus* program also will get some scrutiny in the light of recurring problems.

The House Space Committee also is reported to be considering setting up an aeronautics subcommittee to handle aeronautics portions of the NASA budget, as well as to keep watch on programs of other federal agencies.

The Senate Space Committee is expected to meet almost immediately when the session begins on the draft report containing the committee's reaction and recommendations regarding the post-*Apollo* hearings held last summer. The committee also has indicated that it may begin authorization hearings on the NASA budget early this year, perhaps concurrently with the House in an effort to make ready for an election-year early adjournment. It also hopes to take up the subject of aeronautical research later next spring, following a staff report for which the scientific staff of the Library of Congress is preparing material.

No budget delay—No request to extend the deadline for submission of the budget—set by law at two weeks after the new session begins—is anticipated this year.

The Defense supplemental request is expected to be passed speedily by both Houses. If the defense request does not include funds for additional research and development or procurement of missiles, aircraft and ships, it may be sent directly to the appropriations committees, since no authorization by the Armed Services Committees would be necessary.

Hearings on the budget will begin immediately in the House Armed Services Committee and soon afterward by the Senate Armed Services Committee. This group may again hold hearings jointly with the Defense Appropriations Committee, since so many of the senior members, including chairman Richard B. Russell (D-Ga.) and ranking Democrat John Stennis (D-Miss.)

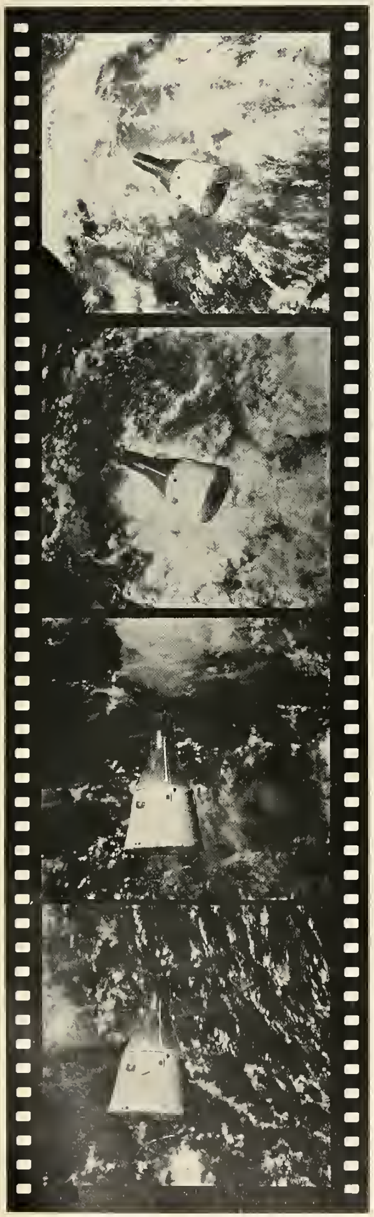
Interest has been expressed in both the House and Senate about the *Manned Orbiting Laboratory,* a decision or lack of it on the *Nike-X,* and Defense Secretary Robert McNamara's decision to develop the B-111 as the bomber force of the future.

The Special Investigations subcommittee of the House Armed Services Committee is expected to keep an eye on the progress of Aerospace Corp. in complying with recommendations made by that group last year, and to take a look at the role of non-profit organizations in general with respect to military agencies.

Also of interest to DOD contractors is the unfinished business of the House Government Operations Committee in the report of the investigation last session on General Accounting Office—DOD—contractor relationships. ■

Gemini 8 May Come in First Quarter

M/R Special report on Gemini success and future—Medics prepared to okay month-long trip; officials say spacecraft closed within one foot



Sequence of photos taken with Hasselblad camera by Gemini 6 astronauts Walter Schirra and Thomas Stafford as they drew close to Gemini 7. First estimates by the astronauts were that they had come within three feet, but NASA officials who examined evidence narrowed this to one foot.

MEDICAL SPECIALISTS at the Manned Spacecraft Center are now willing to give the go-ahead for a month in space on the basis of results from *GT-7* and *6*.

At the same time, Dr. Charles A. Berry called for ground test of 100% oxygen coupled with bed-rest conditions to see whether red blood cell losses observed during the longer flights might be attributable to this or some other factor apart from weightlessness.

Within a foot—Officials at MSC hailed the fact that the two spacecraft got within less than one foot of each other during their rendezvous on Dec. 15 as an indication that docking with another vehicle in space will present no problem.

They indicated that the first docking flight, *Gemini 8,* will be launched in the second quarter of this year. The target vehicle will be the modified *Agena* currently being readied for wind-tunnel tests at the Arnold Engineering Development Center. If modifications to the vehicle have not eliminated the cause of the *Agena* explosion on Oct. 26, a new so-called alternate target docking adapter (ATDA) may be substituted.

While NASA officially holds to a second-quarter launch date for *Gemini 8,* it is reliably reported by informed sources that the space agency actually hopes to get the mission off the ground in the first quarter. A decision as to whether the *Agena* or the ATDA will be used in the flight is expected in late February or early March.

As for missions beyond *8, Gemini 9* will attempt to rendezvous with the *Agena* on the third apogee, or one orbit earlier than the *Gemini 7/6* mission.

Later missions, according to *Gemini* program officials, will attempt a direct-ascent trajectory or rendezvous within one orbit of spacecraft lift-off.

Physicals encouraging—The flights of *GT-6* and *GT-7* more than doubled the U.S. experience in space—bringing the cumulative total from 641 hours 24 minutes and 19 seconds after *GT-5* to 1,345 hours 17 minutes and 45 seconds.

Splashdown for *GT-7* was accomplished at 9:10:25 a.m. EST Dec. 18.

Dr. Berry, chief of Center medical operations and the man with whom the ultimate decision rests as to the safety of the astronauts, told MISSILES AND ROCKETS that it appears that there is a leveling off of effects of weightlessness on the human body. The obvious effects of adaptation which took place during the 14-day flight followed about the same pattern as those in the four- and eight-day flights, with re-adaptation occurring in about the same time as in the shorter flights.

Plotting on a graph, Berry said the Delta of pre- and post-flight tilt table tests was about the same for the eight-day flight as in the 14-day. In other words, from the three-orbit flight on through the four-day flight there was an increase in response to weightlessness by the cardiovascular system. The post-flight heart rates were higher in each flight of longer length, following almost a linear pattern until the eight-day flight.

Preliminary data from the 14-day test falls almost at the same level as the eight-day experience.

Berry said that he was extremely encouraged from these results, especially with the fact that the return to normal was made in almost the same amount of time following the flight.

Heart responses—There was some individual variation in astronaut James Lovell's response. During the first post-flight tilt test his heart rate dropped rapidly after peaking and the test was stopped to make sure that he did not faint. A second test only an hour later showed him to have a normal response, however. Lovell normally has a more labile blood-pressure response than do some of the other astronauts.

Interestingly, however, Lovell was the astronaut chosen for the M-1 experiment, in which pressure cuffs were automatically inflated at intervals to see whether such conditioning measures would lessen the response of the cardiovascular system to weightlessness. On the basis of this flight, Berry noted there appears to be no difference caused by

This special report on Gemini was prepared by NASA Editor Hal Taylor, Space Medicine Editor Heather David in Houston and Contributing Editor Jinx Mercer in Houston, assisted by the MISSILES AND ROCKETS *staff in Washington, D.C.*

using the cuffs. However, other tests—such as the blood volume tests—will show the real effect.

The difference in heart rates observed before and after the missions, from the four-day through the 14-day flights, was an average of about 45. That is, the average heart rate before the flight during tilt was about 85; after the flight it averaged 130 for the six pilots.

In a quick visual survey Berry said the pilots looked even better after *GT-7* than did those in the eight-day mission—an opinion that was shared by many of the medical examiners.

Berry expressed his "innate faith," on the basis of *GT-7*, that the astronauts will be able to adapt to weightlessness, and when the time comes to re-adapt to the gravity state with no real problems. He said that if a decision had to be made at this time to rotate a space vehicle, he would have to rule against it because there is no evidence that it would be necessary.

On the question of whether on-board centrifuges should be included in longer missions, Berry said that while they might be useful for making the astronauts more comfortable, he again was not convinced that they would be necessary.

Blood counts—Blood studies will not be completed for several months, but early results again showed an increase in white blood cell count which lasted for 24 hours.

This phenomenon, since it was first observed in *GT-4* but was almost absent in *GT-5*, was previously thought to be a time-oriented occurrence—something which may have occurred in *GT-5* but which leveled off during the flight and had disappeared before its end.

However, Berry said, *GT-7* showed that the response does not necessarily disappear. He characterized it as an adrenalin-type or stress reaction in which the adrenal glands force neutrophiles into the blood stream. However, it has no great significance, he said, and the astronauts' reactions were the kind which could be observed in almost any football fan before and after a good game.

The blood tests again showed a decrease in circulating red blood cell mass. The red cell counts, or hemaglobin, were down about 1 million red cells, or one gram of hemoglobin. This was in the same "ball park" as previous flights, he observed.

However, doctors have learned from the *GT-7* flight that it appears that the cells are being sequestered in the spleen and being killed off there. This was observed through counting the numbers of tagged red-blood cells, which were found to be doubled in the spleen after the flight.

Bed-rest required—Berry said that it will be hard to determine exactly what this means. However, he said that the other environmental factors of the flight in addition to weightlessness cannot be ruled out at this time.

The 100% oxygen atmosphere used in the *Gemini* flight is one of the factors that needs checking, he observed. In addition, it is known that red-cell mass and circulating plasma decrease during bed rest. However, the direct method of measuring the amounts, which in the *Gemini* flights is by chromium tagging, has not been used in the baseline studies.

What is really needed, Berry said, is a ground-based bed-rest study in 100% oxygen with red-cell mass studies using tagging techniques before and after the exposure. This would pin down whether the atmosphere itself is causing the difference. Decreases in red blood cell count have been reported in earlier 100% oxygen studies—notably one done at Republic Aviation Corp. in 1962.

However, in this effect as in others there appears to be a leveling off in time.

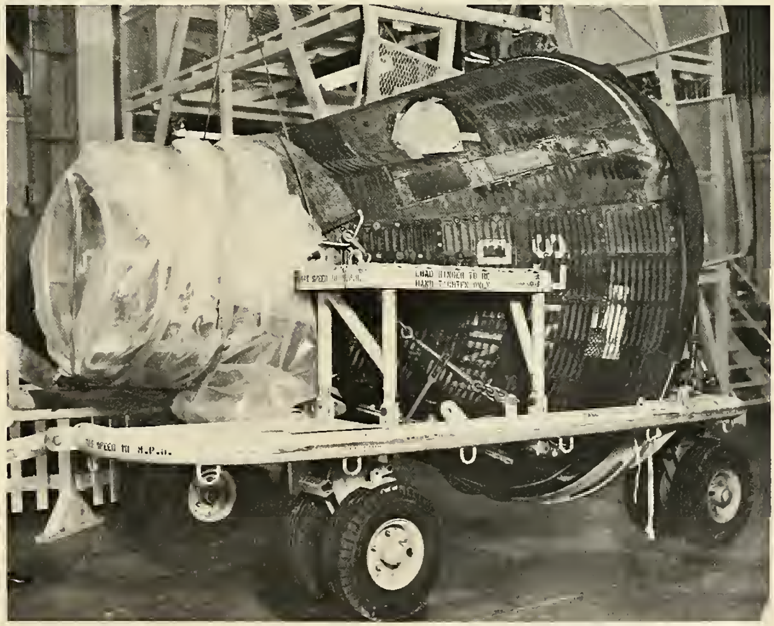
Calcium loss—The big question mark at this point is that of the possible calcium loss experienced by the astronauts. In *GT-4* and *5* it was observed through the bone-densitometry experiment that the astronauts had lost as much as 8-15% of bone mass in the two bones—heel and finger—studied.

Results of the intensive study, in which all calcium intake was carefully governed and all possible sources of loss kept for analysis, may not be ready until March or April, Berry said, because of the nature of the tests that must be performed.

The probability, Berry said, is that the loss of calcium will gradually increase through the longer-duration missions. But he said that he had faith that the problem would be one which could be handled through various means.

There were absolutely no effects such as disorientation or nausea during any of the flights thus far, Berry said. He added that the astronauts were questioned very thoroughly about this aspect, with particular attention to the times when the spacecraft had a high spin rate. He concluded that problems of disorientation must be associated with the training that the men have had—that there could not be that much innate individual difference, although there will be some. The Soviets have reported trouble with the two scientist-cosmonauts in *Voskhod I*, while the trained pilot-cosmonaut was unaffected.

Experiments—The first experiment—M-1, in which a cuff was automatically inflated about the thighs of the astronaut—gave some trouble during sleep hours because of the clanking noise it made while operating. However, in spite of the fact that it was not used later during these hours, experimenters felt that it still constituted a valid experiment in whether the cuffs helped in decreasing effects to the cardiovascular system. Berry said there was no noticeable difference in the responses of Lovell, on whom the experiment was performed, and thus no conclusion could



Gemini 7 spacecraft, shown after recovery Dec. 18, is prepared for detailed examination to determine effects of 14-day mission that doubled U.S. manned spaceflight experience.

be reached that the cuffs had actually helped.

The second experiment—that of exercising with a bungee cord with a known force load to determine the effects on the heart—also showed no change in the cardiovascular system throughout the flight. Blood pressures of the two pilots showed about the same response throughout the flight.

The in-flight phonocardiogram—to determine the fatigue state of the astronauts' heart muscle by measuring the time interval between the activation of the muscle and the actual contraction by correlating heart noises with EKG—was performed and results are now being plotted.

In *GT-4* and *5*, there was no evidence of differences from ground levels, although the Soviets have reported a change in time between the electrical stimulus and muscle reaction during the weightless state. The bone demineralization experiment, in which X-rays were taken before and after the flight, requires several months of analysis. Equipment used was closely calibrated clinical X-ray machines, standard 11-inch by 14-inch X-ray films and calibrated wedge densitometers with three exposures on each bone before and after flight for each astronaut.

The fifth experiment, human otolith function, utilized a visual tester in the form of a special light proof goggles. One eye piece of this contained a light source in the form of a movable white line. The astronaut positioned the white line with a calibrated knurled screw to what he judged to be the right pitch axis of the spacecraft. The second astronaut recorded his performance. Results have been sent to the principal investigator, Dr. Ashton Graybiel of the Naval School of Aviation Medicine, for analysis.

Radiation measurements inside the spacecraft showed a level of about 150 millirads for the mission, the same as from the *GT-5*, in spite of the elapsed-time difference. The fact that the spacecraft was over the South American anomaly for a longer total time was not reflected in the count.

The visual acuity test was only about 80% completed. This was the test in which the command pilot maintained the spacecraft attitude while the pilot observed ground targets and relayed his observations from the spacecraft. Problems in conducting the observations were created by spacecraft position, and the decision not to try the thrusters to conserve fuel towards the end of the mission. However, some identifications reportedly were successful.

Food, water, sleep—In general, assistant medical director Dr. John Zieglschmit told M/R, the astronauts kept up well with their sleep, food and water intake. Food averaged about 2,100 calories a day and water was adequate.

The command pilot slept more fitfully than did the pilot throughout the mission, possibly because of his slightly heavier workload and responsibility. Bodily functions were greatly aided in this flight by the use of the lightweight clothing. Medical personnel said that it also appeared to facilitate sleep.

Furthermore, the condition of the men's skin seemed to be much better because of the lack of humidity through the use of the lightweight garment.

Heart rates during the launch were 150 for Borman command pilot and 132 for the pilot. Borman reached a stabilization in his values after about 2½ hours at about 80 beats per minute. After about 13-14 hours it went to about 70 and kept at a mean of about 70 to 80 throughout the wakeful hours. During sleep periods, his mean heart rate was about 60, with lows of 45 and 47 at isolated intervals. During the moments the pilots sighted a *Polaris* missile which had been launched from a submarine, their heart rates jumped. Borman jumped to 105 while Lovell went to 93.

At post-retrofire, Borman reached a level of 120-135, with a peak of 180 in the downrange communication during re-entry. At these times the pilot Lovell was around 93 to 95, hitting 135 during re-entry.

Lovell's stabilization occurred about 1½ hours after launch and reached a level of between 60 to 65. His sleep lows ranged around 40 to 50 with a low peak of 38 beats per minute.

Blood pressure for both men followed a normal pattern of slight increase after exercise with a mean throughout the flight of about 130/70.

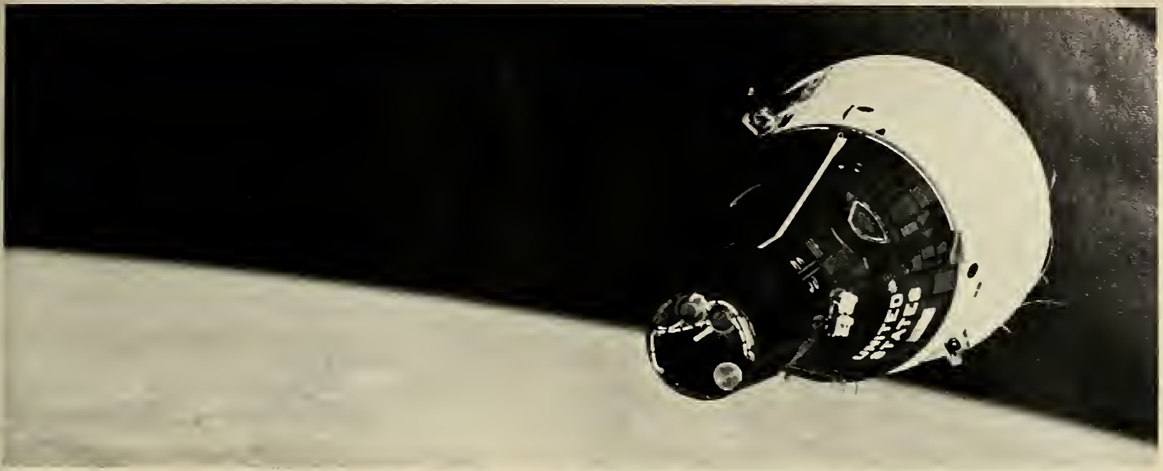
The bioassay of body fluids, in which astronauts reaction to stress during the space flight is calculated, will take several months to complete. Experimenters will be measuring body hormones, electrolytes, proteins, amino acids and enzymes which might be produced because of stress.

The in-flight sleep analysis, through the use of electroencephalogram leads, was successful for the first two nights or sleep periods, but the loads became loose and were not used for the remainder of the flight.

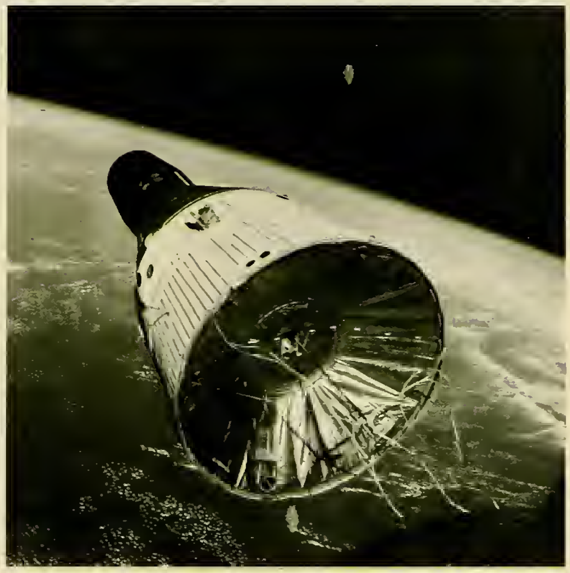
(Continued on page 22)

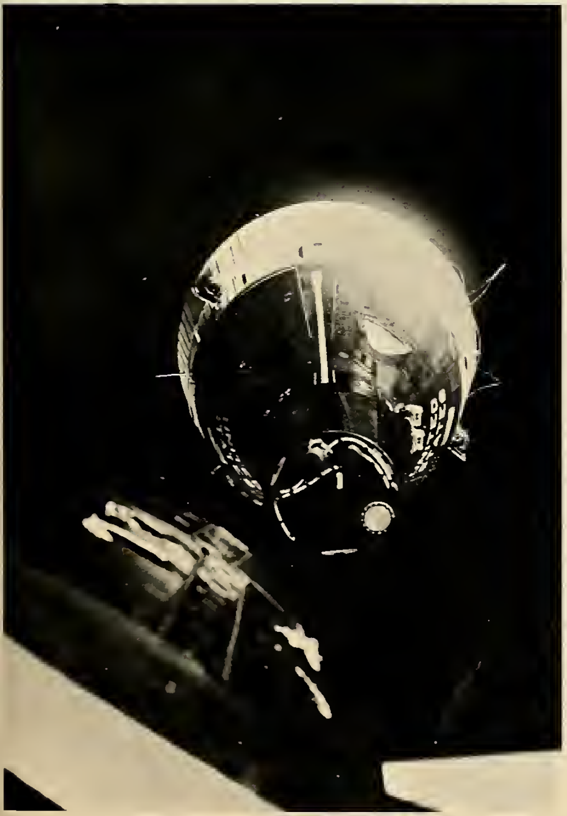
ARGON LASER MODEL

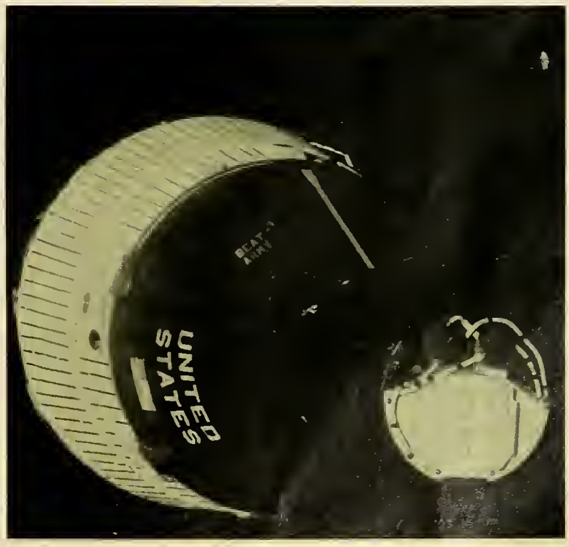
Next Gemini flight will again include an attempt at communication with this laser beacon from Earth. Gemini 7 astronauts locked onto the beacon but lost range before there was time to use it. The ionized argon gas laser is shown here under test at Electro-Optical Systems, Inc., of Pasadena, Calif., where it was initially developed under company funding. The units broacast at varied wavelengths in the visible blue-green spectrum. During space operation, the laser's continuous wave is chopped by a rotating disk.



Above: Gemini 7 during rendezvous and station-keeping as photographed from Gemini 6 with the Earth's curvature as a backdrop. The photo was made Dec. 15 with a Hasselblad camera using Kodak SO 217 film with an ASA of 64. Right: The Gemini 6 spacecraft has moved to a point slightly above and behind Gemini 7 when this view of Borman and Lovell's capsule was snapped by Gemini 6. Bottom right: Borman and Lovell caught this view of Gemini 6 during the historic rendezvous. It shows the "Beat Army" sign Naval Academy graduates Schirra and Stafford flaunted in front of West Pointer Borman. Below: The two spacecraft are nose-to-nose as they move into sunlight. The Gemini 6 crew used the Hasselblad to photograph Gemini 7.







Happy review—With the successful splashdown of *Gemini 7*, the United States racked up a total of 1,356 manned space hours, and, with only docking excepted, has achieved all the major objectives of the *Gemini* program.

The marathon two-week mission flown by Borman and Lovell was the sixth *Gemini* mission conducted during 1965.

"We have put ten men in orbit and brought them safely back," Dr. Robert R. Gilruth emphasized during the post-recovery conference. The director of Manned Spacecraft Center said that during that "fabulous" year *Gemini* astronauts have also demonstrated extra-vehicular activity, rendezvous, controlled re-entry techniques, and have accomplished "a whole raft" of scientific experiments.

Future plans—He added that remaining *Gemini* missions will be more "useful," in that astronauts will begin to apply EVA and rendezvous techniques.

Charles W. Mathews, *Gemini* program manager, explained:

The *Gemini 6* rendezvous was designed around a method that "optimized" the probability of rendezvous at first attempt. Later rendezvous methods will be designed to more closely "match" the *Apollo* constraints, he said.

Gemini 8 will repeat the fourth-apogee rendezvous method. During the same mission, however, a "re-rendezvous" will be attempted to study operations without a computer or radar and using "truly optical techniques." This, he said, is primarily to evaluate whether optical techniques offer a simpler method of rendezvous, or to establish a backup method of rendezvous in the event that electronic equipment necessary to rendezvous fails.

Gemini 9 will attempt rendezvous slightly sooner—at third apogee. Later missions, according to *Gemini* program officials, will attempt a "direct-ascent" trajectory, or rendezvous within one orbit of spacecraft liftoff.

Mathews told M/R that the rendezvous method to be used in lunar orbit after the first lunar-landing mission is still undecided. It is probable, according to astronauts, that the direct-ascent method will not be used, but that a "parking" orbit will be established first by the Lunar Excursion Module. The LEM will then initiate the terminal phase or velocity-matching maneuver with the lunar-orbiting Command Module.

The direct-ascent method is "exceedingly difficult" in that all launch-vehicle dispersions which affect spacecraft altitude, phasing and position (in-plane, out-of-plane) in orbit have to be corrected immediately. Often, the spacecraft's orbital ephemeris cannot be accurately determined until the vehicle is tracked by ground stations along the network for at least one-half orbit.

Remaining *Gemini* missions will also exploit EVA, Mathews said. Tests will include evaluating a number of space tools leading to assembly and disassembly in space. Maneuvering guns, rocket-powered backpacks and other devices providing locomotion in space may be put to use after early evaluation.

NASA earlier last year indicated that *Gemini* astronauts may return micrometeoroid collection plates from *Pegasus*, a satellite orbiting close to manned spaceflight altitudes to investigate the micrometeoroid environment near Earth. The *Agena* is already programmed to carry experimental packages to be retrieved from orbit by *Gemini* astronauts.

Man proves out—The greatest "satisfaction" expressed by NASA mission planners after the completion of the longest manned space flight in history was that man continued to prove himself efficient despite prolonged exposure to a space environment.

This was a major medical demonstration of man's capability to perform useful tasks in space.

Reflecting during the post-recovery conference, Christopher C. Kraft said they had doubts even up to six months ago that man would be able to remain in the cabin for two weeks, "in terms of housekeeping, confinement, comfort, etc."

A major contributing factor was the shirtsleeves (i.e. without spacesuits) environment in which the crew lived during most of the 14 days.

"There's no question in our minds that the way to fly is without pressure suits," Borman commented early in the mission. The crew was able to perform in-flight maintenance, restore loose bio-sensing electrodes, reach around more freely in the cockpit, and even sleep better without suits.

Both men experimented with suit inlet and outlet hose positions in the cockpit for best air circulation and ventilation in an unsuited environment. Later, a similar evaluation was made of the proposed configuration for *Apollo* unsuited operations. Capsule communicater Elliot See said the crew analyzed the cockpit for temperature distribution, location of stagnation points, and hot spots around equipment.

Systems superb—All the systems onboard the *Gemini 7* spacecraft drew unqualified praise. "Getting any system to last 14 days, 24 hours a day, with no major problems is a tribute to the engineering ingenuity of this country," Kraft said.

Especially singled out were the General Electric fuel cells. Kraft credited the electrical power system for giving the spacecraft its long duration capability. "The fuel cells are here to stay." Balkiness, a word used frequently during the two-week mission to describe fuel-cell performance, was attributed to "our not fully understanding how the system works," he said. Fuel cells will fly on all remaining *Gemini* missions, he declared.

The fuel cells began to gain attention during the first orbit. The Delta P light, an indicator of a pressure differential across the membrane separating hydrogen from oxygen gas, flashed red in the cockpit. Since there was no degradation in fuel-cell performance, the experts recommended that the light be ignored.

Midway through the mission, the "faulty" Delta P light begain to gain a little more respect when one of three stacks in section two began to register an amperage drop. Up until that time, the stack had been carrying about 22% of the total load, or about 5% higher than the average load-sharing among the six stacks.

Fuel-cell experts concluded that water was masking the membrane and therefore cutting down its efficiency. They recommended that the stack be flushed independently, the cell (section) be purged more frequently, and that the flow of hydrogen be restricted for short periods to allow the normal flow of oxygen to press the water out of the membrane.

The cell responded by sharing 50% of total spacecraft load and the crew reported that the Delta P light had flickered out momentarily.

As the mission progressed, stack 2C steadily decreased in amperage. During a press conference later, however, Kraft emphasized that there was ample power onboard the spacecraft to complete the mission even if only one section worked.

The cell was open-circuited during sleep periods and when it was brought back on line the following mornings, it showed improved performance. Prior to sleep periods each evening, the section became "balky."

Water withdrawn—This "daily" problem with the fuel cell prompted experts to associate the balkiness with the water pressure balance of the entire fuel-cell system. Because fuel-cell water proved unfit to drink, an elaborate system of tankage was improvised to hold water produced by the fuel cells during the mission. Potable water, stored inside the tankage in special compressible bladders, was kept under pressure for easy withdrawal in zero-gravity by the incoming fuel-cell water.

(Continued on page 26)

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TRW SYSTEMS

Each morning, the astronauts withdrew large amounts of water, which relieved the water back-pressure on the fuel cells. The Delta P light went out, and the fuel cells regained their efficiency level.

This theory was borne out on the eve of the *Gemini 6* mission. Stack 2C was taken off line for a few minutes. When it returned to operation, both Delta P lights flashed on the cockpit panel. At the same time, ground telemetry indicated a significant rise in drinking-water pressure. The surge in pressure was caused by a large "slug" of water being moved out of the stack. The regulators compensated for the pressure differential by increasing their O_2 and H_2 flow rate into both sections. As the pressure decayed, it trapped a relatively higher pressure on the O_2 side of section one and triggered the section one Delta P light. Shortly afterward, the light went out.

It was then concluded that one of two things was causing the problem: a faulty regulator, or a restriction in the water line. A recommendation went up to the crew to withdraw their morning drinking water in smaller increments.

By the twelfth day, two stacks in section two fell below the minimum operating level and were taken off line, and both Delta P lights burned brightly on the cockpit panel. Kraft reassured the crew—by this time somewhat concerned—that there was no degradation in fuel-cell performance, and that ample power was being generated hy the remaining four stacks.

As *Gemini 7* entered its 206th and last revolution before re-entering, the crew was told that the fuel cells could go for another week in orbit.

Annoyances—Minor problems were reported during the mission:

- A tumbling rate estimated at 10 degrees was established through movements imparted by venting from the onboard water boiler. The boiler acts as a coolant early in flight until the radiator takes over, boiling off about five pounds of water. Condensation from the suit circuit drop-by-drop refilled the water boiler and caused it to vent. The tumbling, which was pronounced by the time the crew awoke in the mornings, also disturbed the thermal balance in the cockpit.
- Loss of a PCM delayed-time tape recorder compromised long-term trend data on spacecraft systems and some experiments. The tape became stuck in the rewind position after successfully dumping data over a tracking station. An identical failure was reported to have occurred in the *Gemini 6* spacecraft.
- There was loss of a transducer indicating onboard fuel-cell oxygen quantity through telemetry to the ground. The crew gave quantity readouts verbally.
- A thick film and "grease spots" were deposited on spacecraft windows during the boosted phase of flight. The crew made photometric measurements of light-scattering by the window (part of the visual-acuity experiment) early in the flight and again shortly before re-entry. Researchers hope to determine from this data if depositing increased on the windows during the orbital portion of flight, or whether it occurs only during the launch phase.
- Loss of OS. 3 and 4 right-yaw thrusters prevented *Gemini 7* pilots from photographing the *Gemini 6* re-entry. Borman was able to compensate for altitude, using a maneuvering thruster. Partial use of yaw thrusters was restored just before the end of the mission. The problem was attributed to poor valve seating from frequent use of these thrusters to dampen out tumbling rates.
- During station-keeping maneuvers with the *Gemini 6* spacecraft, Borman reported that the suit inlet hose was "spitting" water and there seemed to to be an accumulation of water in the suit hoses. The ground experts concluded that the water boiler had backed up water into the suit exchanger. The crew was instructed to turn the spacecraft broadside to the Sun and to initiate a 10 deg./sec roll rate to force the water out of the water boiler centrifugally.

Nodal regression—*Gemini 7's* orbital plane proceeded at a rate of 8.7 degs. per day (based on the 29-deg. inclination angle), causing the nodes or the intersection of the plane with equator to shift westward almost 122 degrees over 14 days. This shift of the plane with respect to inertial space caused the spacecraft to pass near U.S. tracking stations a half-hour earlier each day.

The crew's work-rest cycle was synchronized so the awake period occurred during the best passes over the U.S. consequently, the crew was awakened approximately one-half hour earlier each day.

Nodal regression is a first-order perturbation induced by the oblateness of Earth, which caused an out-of-plane "pull" on the orbit toward the equator. Because of gyroscopic action, however, the force instead preceeded the axis of the orbital plane westward about the Earth's north-south pole.

Two more subtle and "higher-order" effects were also blamed on Earth's oblateness:

—A low-frequency "wobble" became apparent in the inclination angle during the two-week mission, shifting it more than a tenth of a deg. over 14 days.

—The orbit became slightly eccentric after it was circularized at 161 n. mi. and actually shifted off-center by 2 n. mi., creating an apogee of about 163 n. mi. and perigee of about 159 n. mi. This shift, described as being periodic in nature, reverses itself about 12½ days later. The orbit loses its eccentricity and becomes circular again, then moves off-center to create an apogee where the perigee was. The line of apsides (major axis) oscillates through the complete cycle every 25 days, according to experts in orbital mechanics.

The *Gemini 7* crew—often hampered by cloud cover over the Earth—still completed about two thirds of the pilot tasks required by the experiments on-board. The experiments included:

Radiometric Measurements (D-4/D-7)—This Dept. of Defense experiment collected a variety of "signatures" in the UV-visible-IR ranges of natural and man-made objects. One of the more spectacular was that of an ion-sheath made by a re-entering vehicle. Borman reported a "bull's eye" in acquiring and tracking a *Minuteman* as it plunged through Earth's atmosphere above Kwajalein Atoll in the Pacific. The missile was launched from Vandenberg AFB, Calif., as *Gemini 7* was nearing communications range of Carnarvon tracking station, on the other side of the Earth in Australia. The launch was timed to re-enter the vehicle at night and near the spacecraft. Precise times coupled with precise pointing angles "cued" the crew to the re-entry location. The closing velocity between the two vehicles was approximately 29,000 mph. Earlier, the crew successfully tracked a *Polaris A-3* missile launched from a submerged submarine, obtained IR signatures of a rocket sled at Holloman AFB, N.M., and collected UV reflectance data from a full Moon.

Optical Communications (MSC-4)—A flashing, argon gas laser beacon on the island of Kauai, Hawaii, was acquired by the crew and easily tracked. Lovell followed the beacon through the eyepiece of a gallium-arsenide laser transmitter, locked on, and by depressing a lever automatically modulated the 9,000-angstrom wavelength with a 100 pps signal. Kauai test personnel reported that an intermittent signal appeared to have been received on the ground. Film records which would verify this have not been completely processed.

The experiment was rather severely constrained by a last-minute decision to change *Gemini 7's* launch azimuth in order to provide better launch opportunities for *Gemini 6*. The target's plane was inclined to the equator at 28.87 degs. instead of the earlier-planned 32.5 degs. The experiment's primary ground re-

(Continued on page 31)

Space-Age Boeing Openings for Engineers and Scientists

The Boeing Company's deep involvement in the nation's most important missile and space programs is providing qualified engineers and scientists career opportunities of unusual scope and growth potential. Boeing currently is weapon system integrator for the U.S. Air Force advanced Minuteman II ICBM, prime contractor for the National Aeronautics and Space Administration Lunar Orbiter moon-scanning satellite, and a major contractor on the NASA Saturn V launch vehicle.

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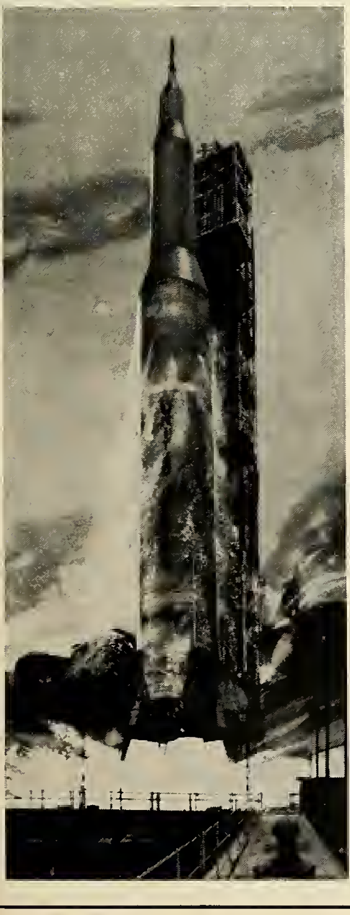

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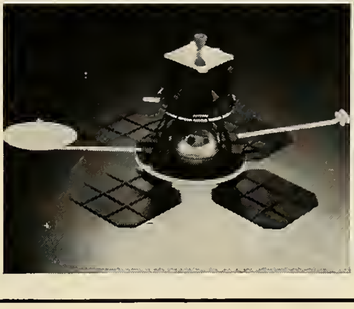
First Lunar Orbiter flight, scheduled for mid-1966, will seek out Apollo landing sites with sharp, detailed photographs of moon's surface. Boeing is building eight Orbiters for NASA.



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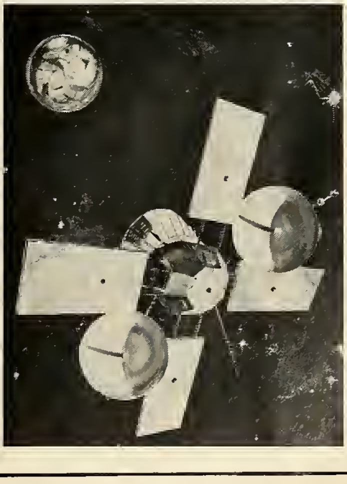
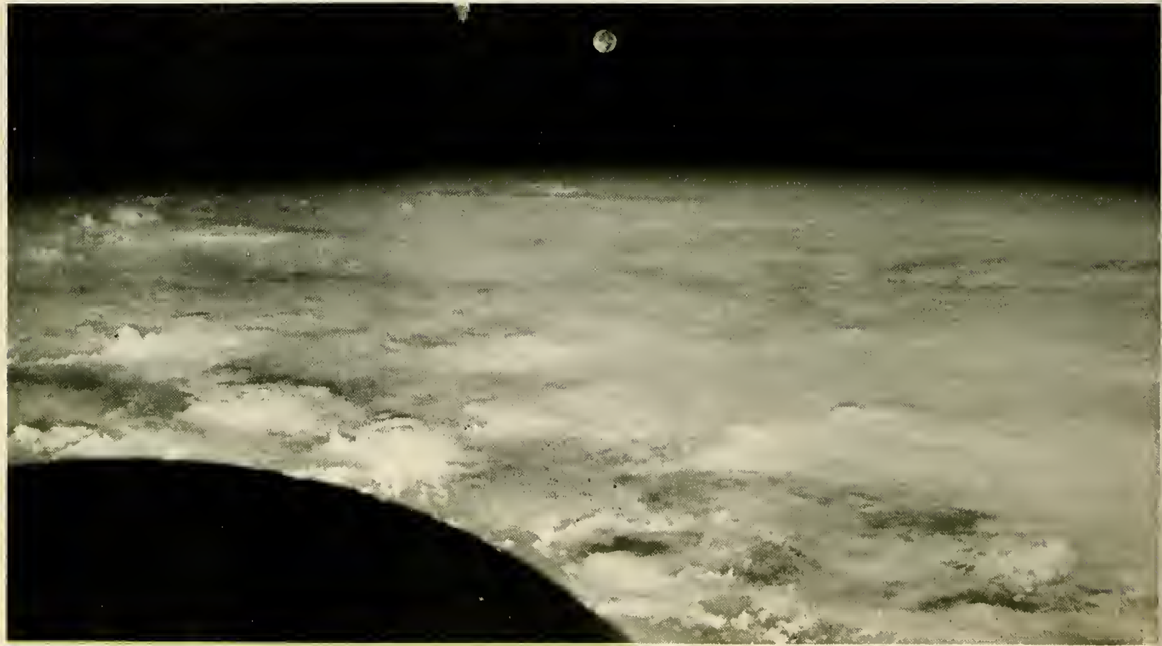
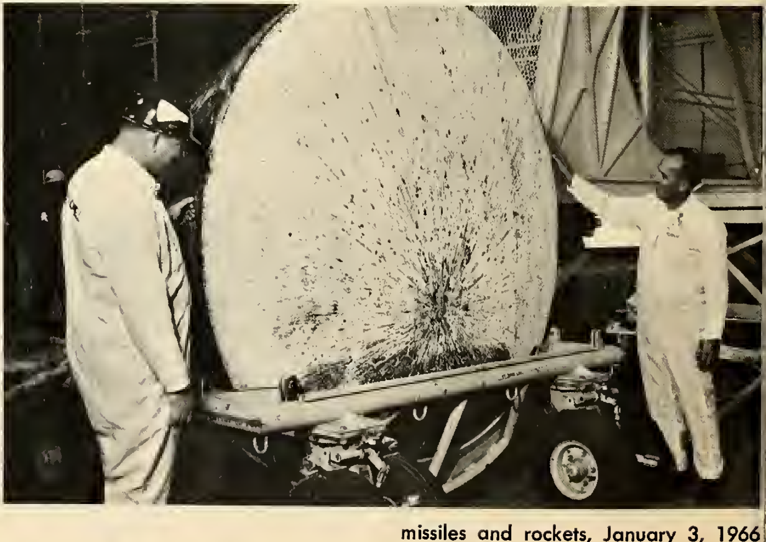
Computer Systems Analysis
Plant Facilities Engineering
Manufacturing Development
Welding Process Development
Brazing/Diffusion Bonding
Arming & Fuzing Technology
Tool Design
Quality Control
Management Systems Staff

Artist's early concept of unmanned Voyager spacecraft, which will explore the planets, beginning with Mars in early 1970's. Boeing is one of three companies picked by NASA for preliminary design studies.







Top left: Gemini 7 command pilot Frank Borman as photographed inside the spacecraft by pilot James Lovell. Photo was made from one frame of a 16mm motion picture film exposed in a Maurer camera using Kodak SO 217 color film. Top right: Borman uses a vision tester in the M-9 experiment designed to test orientation capabilities during weightlessness. He held tester by its bite board and fitted binocular pieces over his eyes, then was required to adjust a white line target so that it appeared to be aligned with the spacecraft axis. Lovell recorded Borman's settings on special data cards. Above center: View of Moon photographed from Gemini 7 with a 70mm Hasselblad camera using Kodak SO 217 MS film. Right: Effects of re-entry heating show on Gemini 7 heat shield.

ceiver site at White Sands Missile Range, N.M., was no longer ideally located for a fair test of laser communications, and two field stations were hastily assembled on Kauai and Ascension Islands. Equipment problems plagued both sites mercilessly, and when the equipment was "up" the sites were "down" due to cloud cover. During the 14 days, there were only two passes when all conditions were favorable.

Visual Acuity (S-8/D-13)—Pilot scores in daily self-checks of vision indicated that there was no apparent change in visual acuity at least up through 14 days in a weightless environment, visibility laboratory representatives said after studying preliminary data. Ground targets situated north of Laredo, Tex., were successfully located through three passes early in the mission, and the orientation of the markings easily read. Cloud cover prevented the pilots from seeing the targets on later passes.

Star Occultation Measurements (D-5)—This DOD experiment to evaluate an autonomous navigation technique was scrubbed in-flight after an intensive but unsuccessful effort to calibrate the photometer. The D-5 equipment failure also compromised another experiment—landmark contrast measurements (MSC-12)—which required photometric measurements of prominent landmarks.

Simple Navigation (D-9)—Pilots used a hand-held space sextant to measure star-to-horizon, and star-to-star angles through five night passes. The DOD experiment monitor said the crew completed all the measurements with no difficulty.

M Radiation Measurements (MSC-2, MSC-3)—By extending a tri-axis, fluxgate magnetometer and a proton-electron spectrometer out from the adapter on a boom, measurements were obtained of the radiation environment immediately outside the spacecraft as it moved through the South Atlantic geomagnetic anomaly. Approximately 5 to 8 times each day the spectrometer recorded the energy ranges of protons and electrons, and the magnetometer correlated this data with direction and magnitude of the Earth's magnetic field lines in relation to the spacecraft. The experiment was completed successfully.

Synoptic Weather and Terrain Photography (S-6, S-5)—Although extensive cloud cover over most of the Earth hampered some experiments throughout the two-week mission, it provided an infinite variety of cloud systems for the crew to photograph with the onboard Hasselblad camera. Areas below the clouds of special interest—the Bahamas, the Red Sea, and West Central Mexico—were a little more difficult to photograph.

Dim Light Phenomena—The crew found several opportunities to photograph airglow and other dim light phenomena, including Aurora Borealis. ■

Manned Spacecraft Center Officials Praise Incentive Contribution to Gemini Progress

NASA OFFICIALS in Houston are hinting broadly that the *Gemini* program is getting its steam from incentive contracting.

As 1965 drew to a close, the Manned Spacecraft Center had chalked up seven of the 12 missions in the program. Six of these—*Gemini-Titan 2* through *Gemini-Titan 7*—were accomplished under the converted McDonnell Aircraft Corp. contract.

The conversion from a cost-plus-fixed-fee (CPFF) to a cost-plus-incentive-fee (CPIF) was announced one year ago this month.

MSC procurement officials departed from the traditional incentive contracting techniques when they renegotiated the basic $712-million contract.

Traditional methods, according to Glenn F. Bailey of the Procurement and Contracts Div., called for an incentive fee to be paid separately for each incentive parameter. "There was no way to shift incentive emphasis to achieve a particular mission objective."

NASA's objective was to achieve a high degree of performance at a cost as low as possible.

MSC reviewed the program and worked up a cost range within which it felt the contractor could operate "with some maneuverability," Bailey said. "The more he could reduce cost, the more he could earn."

The second criterion emphasized performance and was based on a "point system." Simply, it judged how well the spacecraft performed during the mission.

Flexible point system—The incentive arrangement differed from the "ordinary" incentive contract in that cost and performance were integrated according to a computed ratio which could be varied from mission to mission to meet the particular objective.

Systems performance was rated highly on early *Gemini* missions. *GT-2*, an unmanned mission, was rated at the maximum 10 points because the emphasis here was on the performance of on-board systems before the program moved into manned missions.

Bailey explained it this way:

If the particular objective of the mission is met, the contractor wins his points. He would earn the points even if a vital on-board system, such as the radar, failed to work and the pilots completed the rendezvous through other methods.

Similarly, although problems had developed with fuel cell and associated systems during *GT-5* and *GT-7*, they did not compromise the basic objective: long-duration flight.

Some areas, Bailey pointed out, are not so clearly defined:

The failure of the *Gemini 4* computer will cost points if it is proven that the malfunction was created by a part of the computer. On the other hand, if the malfunction occurred due to pilot error, the contractor is faultless.

Early delivery bonus—Under this incentive arrangement, McDonnell can earn the full allowable profit of 15%, Bailey said. Under a separate agreement, covering scheduled delivery of spacecraft, McDonnell can boost its earnings even more substantially.

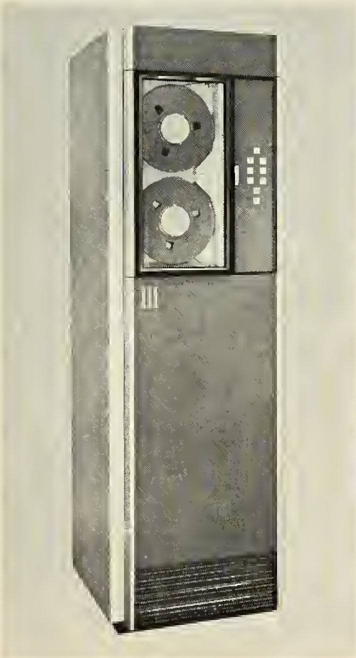
McDonnell can earn $5,000 per day for each day up to 30 days that it delivers a spacecraft ahead of schedule. By the same token, it can lose $5,000 per day up to 30 days for late delivery. The maximum award under this clause, which took effect with the delivery of spacecraft 7, is about $900,000.

Although the money involved in the scheduled delivery clause is "insignificant," Bailey said, it had proven to be "the most valuable thing in the program."

He added, "it has made everyone schedule-conscious, from the manager down to the lowest supervisory staff. For the first time, we are ahead of schedule."

New from CEC...

the first truly universal digital magnetic tape system



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Check the following advantages, and you will see why the DR-3000 is the obvious answer for so many digital data processing requirements.

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2 **Versatility.** *Both* high or low speed applications. The most compact system made, it will mount 2 or 3 to a rack — even fit through a submarine hatch. It is available in horizontal or vertical cabinets. Ruggedized for semi-mobile or extreme environments, it provides a complete selection of input/output logic levels. It is the ideal unit for most commercial or laboratory data processing systems.

3 **Operator convenience.** The DR-3000 is the easiest of all to load due to a straight tape loading path which requires no threading. The entire operation takes less than 10 seconds. Front access only is required for all normal maintenance. In addition, a complete selection of IBM-compatible accessories is available.

4 **Formats.** 7 channel 729 series or 9 channel 360 series formats are standard, reading and writing at 200, 556, or 800 bpi — plus 1600 bpi phase-encoded format available on special order.

5 **Reliability.** Only field-proven design concepts are used. Dual capstans with rugged drive actuators provide positive drive. There are no belts or mechanical linkages to cause tape slippage or creep. Air bearings virtually eliminate tape friction. CEC-built all-metal-front-surface read/write heads have achieved *over 12,000 hours* operational life in field environments. All electronics are modular and solid-state.

6 **Performance.** The DR-3000 assures the most performance per dollar available today. Fast start/stop characteristics provide complete unrestrictive programming up to 200 commands per second. There are 84 inches of tape buffering. Tape speed variation is less than ±0.5%.

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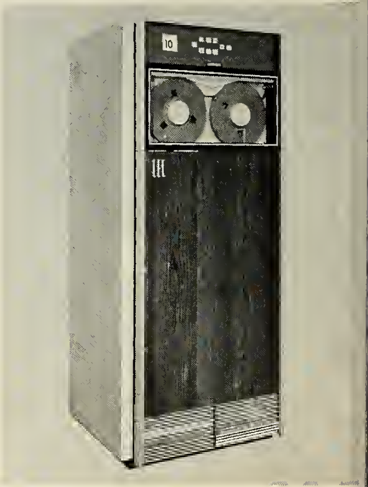

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Standard ½" tape, 7 or 9 channels • Tape speeds — 37½ or 75 ips standard IBM formats • Operates at 200, 556, 800 bpi NRZ or 1600 bpi phase-encoded • Start time — less than 4 msec • Stop time — less than 3 msec • Rewind — 2400 feet in 2½ minutes • Bit dropout rate less than 1 in 10^7 • Maximum total skew — within full IBM machine-to-machine compatibility at all speeds • Average tape speed accuracy — within ±0.5% of absolute • Cycling rate — 200 commands-per-second without programming restrictions • Power — 1 kva • Size — 19" x 24½" x 13½" • Weight — 135 lbs.

For all the rewarding facts about the DR-3000, call CEC or write for Bulletin 3000-X4.

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Technical Countdown

ELECTRONICS

Titan III To Get New Computer

A Univac 1824 thin-film computer has been selected by the Air Force and Aerospace Corp. to replace the existing IBM guidance computer in *Titan III*. Reportedly, a contract was expected to be issued last week to the Sperry Rand Div. from AC Electronics Div. of General Motors, *Titan III* guidance system associate prime contractor. The reason for replacement of the key subsystem appears to have resulted from the more complex missions planned for the vehicle in the *MOL* program. The Univac system, informants report, is smaller, lighter in weight, and because of its thin-film memory (instead of the IBM drum memory), is more quickly responsive to command. (It also has been reported that the Univac 1824 has been adapted for use on all currently planned Air Force re-entry projects.)

Link Apollo Simulator Delivered

The primary training system for astronauts preparing for round trips to the Moon has been shipped from North American's Space and Information Systems Div. to NASA's Manned Spacecraft Center, Houston. This *Apollo* mission simulator was produced by General Precision's Link Group under contract to S&ID, and stands 30 ft. high, weighing 40 tons. Mathematical models simulate the *Apollo* spacecraft and its subsystems during mission phases. Visual systems, to be completed later, will present a simulated space environment. A second mission simulator is under construction at Link for use at Kennedy Space Center. The group is also building two lunar excursion simulators for Houston and Kennedy Space Center.

IC Forecast: Three-Cent Computer Circuits

By 1970, integrated circuit manufacturers are likely to be producing 65,000 devices on a ¼-sq.-in. plane—or the equivalent of 3,250 circuits on a single die, Rex Rice of Fairchild Semiconductor told the Fall Joint Computer Conference. Including packaging and testing cost, the circuits would sell for about $100, or 3 cents per circuit. Ten wafers might be used in a 36-bit array memory, said Rice, at a total cost of about $1,200. The 32,500 circuits could handle more than 560 two-bit words, probably as many as 1,000 words, said Rice. Speeds would be in the 50 to 100-nanosec. range. Discussing means of getting the yields necessary to make this technology feasible, Linder C. Hobbs, Hobbs Associates, said his opinion was that cellular logic would not be necessary. Yield gains will come from computer-controlled fabrication of masks and process optimization, he said.

PROPULSION

SPARM Flight Test Due This Month

First powered flight of the Solid Propellant Augmented Rocket Motor (SPARM) drone over the Pacific Missile Range is expected to take place this month. In demonstration tests sponsored at Pt. Mugu by the Air Force Directorate of Armament Development, the engine will fly in a modified AQM-37A target provided by Beech Aircraft Corp. Before free flight, the SPARM vehicle will be carried captive on its F-4B launch aircraft to check out aerodynamic characteristics. The standard Beech AQM-37A flies at Mach 2 at 70,000 ft. The SPARM vehicle will operate at the same altitude but considerably increased speeds. Modifications to the vehicle include enlarging the wing area and engine compartment to accommodate the larger and heavier SPARM engine. The engine, developed by Thiokol Chemical Corp. under a DOD contract, combines a booster and sustainer in a single package.

Five-Year Test Period Reached

The fifth anniversary of testing of the 1.5-million-lb. thrust chamber of the F-1 engine was reached at Rocketdyne's Edwards Field Laboratory Dec. 17. About 1,545 thrust chamber tests have been carried out in the five-year period for a total of 8,196 seconds. Over this period the F-1 test program has consumed 89,400,000 gallons of liquid oxygen and 33,433,400 gallons of fuel (RP-1).

NAA Saturn Personnel Move Planned

More than 700 persons in North American's Space and Information Systems Division will be relocated from Downey, Calif., to the Seal Beach plant. The moves are designed to consolidate *Saturn S-II* manufacturing operations at Seal Beach. Chiefly involved in the transfer are groups working in the insulation, cable design, and structures area. The move is to be completed about the middle of the month. In another *S-II* program move, 219 persons in *S-II* engineering automatic checkout electronic design were transferred from Downey to Compton.

SPACE MEDICINE

Anti-Radiation Agent Suggested

Air Force doctors at the School of Aerospace Medicine suggest that ascorbic acid warrants testing as a radiation protective agent in animals, since it would seem to have more promise than sulfhydryldisulfide protective agents because of its relatively low toxicity. Research has shown that ascorbic acid in low concentration can protect enzymes in highly concentrated solutions, when irradiated with Co 60 gamma rays, and that it is excellent as a protective agent for erythrocytes. Trials on animals thus far as reported in the literature have been few and inconclusive, and SAM plans a comprehensive test in its laboratory.

Monkey Fine in 100% Oxygen Test

A 73-day test of the 5-psi, 100% oxygen atmosphere of *Mercury, Gemini* and *Apollo* using one monkey showed no physiological or psychological effect from the environment, NASA Ames Life Sciences' director Dr. Harold Klein reports. The testing included electroencyphalograms, electrocardiograms, blood pressure and other physiological parameters, as well as psychomotor tests. According to Klein, the monkey's weight and appetite as well as physiological measurements were entirely normal.

Europeans Frustrated in Space Hopes

OECD study shows how lag in R&D investment hobbles both individual and cooperative efforts; Johnson offer may open way to participation

by William S. Beller

PRESIDENT JOHNSON'S recent beguiling offer to European nations to consult with those wishing to join this country in "a major endeavor" in space exploration may help stem the growing dissatisfaction of many of Europe's leaders with the minuscule roles their countries are playing in the space field.

The President's offer, made late last month during the visit of West German Chancellor Ludwig Erhard to the United States, did divert attention from the more immediate question of whether West Germany should have a hand on the nuclear trigger.

Yet the President left no doubt that his major concern was in getting European nations to participate in space research and development in a significant way on a long-term basis. This was evident from his singling out such joint new ventures in space as probes to the Sun and Jupiter, and announcing his intention to send a high-level commission, headed by NASA Administrator James E. Webb, to Europe early this year to work out the details.

Some reservations—The fear of becoming a second-class nation has prodded nearly every industrial nation into taking a hand in military and space R&D. The feeling has been that this work would somehow lead to a U.S. type of industrial competence and a large fallout of modern services and commodities for a country's civilian population.

The prod, though, is being blunted by the seeming lack of "fallout" from either the U.S. or the Soviet Union proportionate to the huge sums these nations are spending on defense and space. An end-of-the-year report by the Organization for Economic Cooperation and Development (OECD) suggests that some of the same R&D results might be obtained much more cheaply by governments willing to give direct aid to nondefense research and development. The report noted the limited and shrinking value of R&D when it is delivered as a "bunker shot" off the military and space sector.

OECD was set up under a Convention signed in Paris on Dec. 14, 1960, "to contribute to sound economic expansion in member as well as non-member countries in the process of economic development." Members are Austria, Belgium, Canada, Denmark, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

The possibility that European nations may abandon their hope and even their desire to engage in major space programs is not remote. Observers point to 1) the relatively small amount these nations are spending on pertinent R&D; 2) the obvious dissatisfaction with NASA's refusal to cooperate on space programs unless they are nonduplicative of the space agency's and have scientific, as opposed to engineering, merit; 3) in the same vein, NASA's lack of financial interest in European-proposed projects such as *Aerospace Transporter* and *Lunar International Laboratory.*

Unready Eurospace—For several years, European industrial leaders have been straining to get some space work. They have organized themselves into Eurospace, to promote a means of doing it, but unhappily have not found any major projects to perform for lack of financing and objective.

Their attitude is easily interpreted as indecisive, which was remarked by Rep. Joseph E. Karth (D-Minn), chairman of the Space Sciences Subcommittee of the House Space Committee. He told of a recent conference with European industrial leaders in which he could not get a single definitive answer on what space projects they would like to undertake or even are capable of undertaking.

The congressman told MISSILES AND ROCKETS that the *Advanced Orbiting Solar Observatory (AOSO)* could be a good candidate for a European space project as long as the U.S. doesn't do it itself. "But I'm not sure that this (project) is off after 1966."

He stressed that the determination is theirs to make. He said he was "sadly disappointed (the Europeans) didn't have one project, program, area in mind." He added that, "about all we can do is offer suggestions—and I support greater cooperation. After their determination, we can evaluate it. But, they have to tell us what they want to do."

Lopsided ratio—About 60% of total R&D expenditures both in the United States and the Soviet Union in 1962 were for military and space research, according to the OECD report on the R&D effort in Western Europe, North America and the Soviet Union. The report says that in Western Europe, the average proportion is much lower; only in France does it approach the U.S. level. In the United Kingdom in 1962 it amounted to about 40% of the total; in Germany in 1962, only about 10% of total expenditures. "For Western Europe as a whole, probably only about a third of total R&D expenditures was devoted to military and space research."

This comparison can be carried a step further and given in terms of the ratio of gross expenditures for R&D to Gross National Product (GNP). On this basis, the U.S. ratio of expenditures to GNP in 1962 was 3.1%, as compared with the United Kingdom's 2.2%, and significantly decreasing ratios of other European countries. Most of the underdeveloped countries have "research ratios" of less than 0.2% of GNP according to the OECD.

The Soviet Union's ratio—estimated conservatively and using a current estimate of GNP expressed in European terms—is said to be over 2.5% and could be well over 3%. "Taking into account the relatively low cost of research and development in the USSR this is a high ratio," says OECD.

The agency points out that Japan also shows an exceptionally high ratio in relation to GNP, in part due to an extremely ambitious program of rapid industrialization and economic growth linked with large-scale educational expansion.

Deceptive deficits—A clear mea sure of the success of the mammoth U.S R&D effort can be given in terms of "technological balance of payments." In this measure, a nation compares its payments to other countries with its receipts for technical advice, licenses and patents. Thus, an underdeveloped country trying to industrialize would have high expenditures relative to its receipts, and therefore would be supporting "deficit" spending until it reached industrial and scientific maturity. By this figuring, a developed country would have a high technological balance of payments.

The ratio, however, should be treated with caution. An unfavorable balance in some instances can mean that a country is buying know-how as the most efficient means of acquiring it, or a developed country has become complacent and is living on its past investment in R&D.

The United States' high ratio is unavoidably ascribed to high R&D effort. The question in the minds of Europeans is how much the ratio is built up by military and space R&D.

OECD points out that the unfavorable balance of the Western European countries comes chiefly from their heavy and growing deficit with the United States. Two-thirds of the total French deficit and half the total German were due to this. The inescapable conclusion is that America is in the technical lead in most industries, although not in all.

OECD gives these figures: the ratio of payments to receipts was 2.7 for Germany (1963) and France (1962) for all transactions; but for their transactions with United States, the ratios were 4.8 and 5.0, respectively. The United Kingdom ratio for transactions with the United States in 1961 was, similarly, 5.1.

In the overall picture, Western Europe, including the United Kingdom, paid the United States $250 million in 1961 for technological aid and received only $44 million. This $206-million deficit compares with a deficit of $111 million in 1957, indicating that Europe may be falling behind in the technological race. The ratio of payments to receipts for 1961 for Western Europe as a whole, in its transactions with the United States, was 5.6.

By industries—An analysis of the technological-balance-of-payments figures also give an indication of the industries in which the American lead is most marked.

Specifically, while the German ratio of payments to receipts with the U.S. is 5.0 for all industries, it is only 1.8 for the chemical industry, where German R&D effort is particularly strong. The story is different for metals, machinery, and vehicles, where the ratio is 7.0, and for electrical machinery and devices, where it is 15.0. A similar profile was seen with respect to the other countries.

ESTIMATED GROSS EXPENDITURE ON RESEARCH & DEVELOPMENT (GERD), 1962

	CURRENCY	NATIONAL CURRENCY	$ US Millions OFFICIAL EXCHANGE RATE	POPULATION (Millions)	R & D EXPENDITURE PER CAPITA—$ US OFFICIAL EXCHANGE RATE	GNP AT MARKET PRICE	GERD AS % OF GNP AT MARKET PRICE %
United States........	$ Million	17,531	17,531	187	93.7	557,590	3.1
Western Europe*....	—	—	4,360	176	24.8	—	—
Belgium............	Million Francs	6,625	133	9	14.8	646,200	1.0
France.............	Million Francs	5,430	1,108	47	23.6	356,300	1.5
Germany...........	Million DM	4,419	1,105	55	20.1	354,500	1.3
Netherlands........	Million Florins	860	239	12	20.3	48,090	1.8
United Kingdom....	£ Million	634	1,775	53	33.5	28,566	2.2

* Belgium, France, Germany, Netherlands, United Kingdom.

ESTIMATED MANPOWER ENGAGED IN RESEARCH & DEVELOPMENT, 1962

	SCIENTISTS AND ENGINEERS ENGAGED in R & D	OTHER PERSONNEL ENGAGED in R & D	TOTAL PERSONNEL ENGAGED in R & D	TOTAL POPULATION	TOTAL WORKING POPULATION (AGED 15-64)	R & D PERSONNEL PER 1,000 POPULATION	R & D PERSONNEL PER 1,000 WORKING POPULATION
	('000's full-time equivalent)	('000's)	('000's)	(millions)	(millions)		
United States............	435.6	723.9	1,159.5	186.6	111.2	6.2	10.4
Western Europe*........	147.5	370.8	518.3	176.1	113.9	2.9	4.6
Belgium................	8.1	12.9	21.0	9.2	6.0	2.3	3.5
France.................	28.0	83.2	111.2	47.0	29.1	2.4	3.8
Germany...............	40.1	102.1	142.2	54.7	36.7	2.6	3.9
Netherlands............	12.6	20.2	32.8	11.8	7.3	2.8	4.5
United Kingdom.........	58.7	152.4	211.1	53.4	34.8	4.0	6.1
USSR [1].................	416	623	1,039	220	142	4.7	7.3
[2].................	487	985	1,472			6.7	10.4

* Belgium, France, Germany, Netherlands, United Kingdom.

[1] Conservative estimate

[2] Probable number

The most interesting figures would be from the viewpoint of the United States. Unfortunately, OECD has these only for 1956. Since that time the pattern surely has become bolder. In 1956, the American overall ratio was highest in electrical machinery and electronics, with receipts 30 times as big as payments; in other machinery, 22 times; motor vehicles, 11 times; and other transport equipment, 6 times. In chemicals and petroleum products, the ratio was only 3, compared with an average of 6 for all industries.

The OECD data on manpower confirmed the agency's estimates that the real resources devoted to R&D are between 2 and 3 times as great in the United States as they are in Western Europe. In the United States, 6.2% of the nation's total population is employed in R&D activities, compared with 2.9% in Western Europe, according to the OECD. Based on an extremely conservative estimate, the comparable figure for the Soviet Union is less than 6.2%—but on a more realistic basis "is the same as that of the United States." The emphasis the Soviet is putting on R&D work is reflected in the vast increase of R&D manpower, more than tripling in number since 1955.

Curatives—The OECD proposes three ways to close the gap in the scale of resources committed to R&D between the United States (and the USSR) on the one hand, and Western Europe on the other:

—Development of joint Western European intergovernmental research projects on a large scale.

—Self-regulating tendencies in the business enterprise sector—for example, through American firms shifting their research activities to Europe because of lower research costs.

—Independent government policies to stimulate research activity in the principal Western European countries at a faster rate than either the United States or the USSR, or greater efforts in the company-financed sector.

President Johnson's willingness to cooperate with Western Europe on major space projects could be a fourth way. ■

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The Industry Week

Mergers and Acquisitions

Technical Operations, Inc., Burlington, Mass., has purchased Viso Corp., Detroit, manufacturer of isotope radiography equipment. The firm has also acquired a line of battery chargers previously manufactured by Hughes Electronics Co., Los Angeles. Production facilities will be moved to Burlington. . . . *Gardner-Denver Co., Quincy, Ill., plans to acquire the Martin-Decker Corp., Long Beach, Calif., for about $5.8 million of stock. Martin produces instruments and recording devices for use on test gauges. Gardner manufactures a wide range of construction and industrial equipment.* . . . The Liquidometer Corp., Long Island City, N.Y., a wholly owned subsidiary of Simmonds Precision Products, Inc., has been established as a Simmonds division. Simmonds is located in Tarrytown, N.Y. . . . *Avnet, Inc., New York City, is planning to purchase all outstanding shares of Busacker Electronic Equipment Co., Inc., Houston, in exchange for convertible preferred Avnet stock.* . . . Majority control of Elpac, Inc., Westminster, Calif., electronics manufacturer, has been acquired by Robert L. Burr. The firm has purchased Double-E Products, El Segundo, Calif., manufacturer of passive filters. Double-E operations are being integrated into the Elpac components facility in Fullerton, Calif. The company is also establishing a new Systems Div. in Westminster.

International

Telonic Industries, Inc., Beech Grove, Ind., has set up two European offices to maintain the firm's stocks of instruments, accessories and parts. Telonic Industries GmbH has been established as a wholly owned subsidiary in Frankfurt am Main, Germany. Telonic Industries U.K. has been set up as a corporate division in Maidenhead, England. The firm also named two new European distributors—Inelco Belgium Co. and Inelco Holland Co. . . . *A $3-million optical telescope will be constructed in New South Wales, Australia, the University of Sydney has announced. The 84-in. telescope will be built by the Cornell-Sydney University Astronomy Center to work in conjunction with the Mills Cross radio telescope opened near Canberra last year.* . . . TRW Inc. has announced that Morgan Grenfell & Co. Ltd. of London has made a formal offer on behalf of TRW to purchase for approximately $28 million in cash the outstanding shares of Clifford Motor Components Limited, a manufacturer of automotive valves, valve gears and steering wheels with factories in the English Midlands and Kent. It is expected that the sale will be completed early this year.

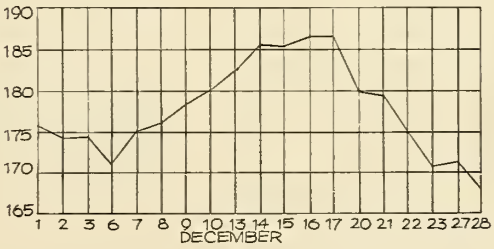
Comsat Corp. Cash Position Down

Communications Satellite Corp. has announced a cash deficit of $5,682,720 for the first nine months of 1965, but cash investments and cash in hand still amount to more than $187 million. According to a recent announcement, the firm's receipts for the period were $10,933,547; total disbursements were $16,616,267. Receipts included $965,896 in operating revenue from the *Early Bird* satellite. Other income included investment of other nations in the global satellite system and interest from cash investments. The company has said that it won't issue a profit-and-loss statement until it gets fully into the development of the global system. Joseph V. Charyk, Comsat president, has estimated that it will be the late 1960's before the company shows a profit.

Facility Expansions

International Telephone and Telegraph Corp. has started construction of a $700,000 manufacturing plant in Monroe, La. The facility will produce industrial relays and equipment control valves. . . . *S & S Associates, Inc., has been relocated to Boro Line Road, King of Prussia, Pa. The firm is an engineering marketing company in the electronics field.* . . . Planning Research Corp., Los Angeles, has opened a branch office in Rome, N.Y. The office will support the firm's contracts with Rome Air Development Center. . . . *NASA has dedicated a new space radiation effects laboratory and nuclear science building at Newport News, Va.* . . . Dumont Aviation Associates is constructing a manufacturing facility in Lakewood, Calif. . . . *A 475,000-share ($5,106,250) offering of common stock of Rocket Research Corp., Seattle, Wash., was completed on Dec. 22 by Dempsey-Tegeler and Co., Inc., and associates. The company offered 398,000 shares and selling stockholders offered 77,000. Stock was sold at $10.75 per share, and the issue was oversubscribed. Rocket Research, which specializes in control rockets, gas generators, high-energy propellants and explosives, said it will use proceeds of the sale to acquire additional laboratory and manufacturing facilities, as well as to increase its working capital.*

Missile/Space Stock Index



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TV System Faces Severe Saturn V Test

Unit designed to study in-flight S-IC stage engine function; L-band transmitter development represents significant advance

by Rex Pay

A HIGH-RELIABILITY television system on stage one of *Saturn V* will transmit four views of engine operation and other functions through a single solid-state L-band transmitter as the giant booster climbs into orbit.

Designed by the Boeing Company's launch systems branch in New Orleans, the system has four rotating fiber-optics viewing systems and two cameras. Operating in the severe environment of the S-IC stage, it will represent a considerable advance in the state of the art of television applications.

One of the principal items to be studied in flight will be engine operation, including gimballing. However, the high radiant heat flux at the viewing point will make it impossible to locate a television camera there. Instead, a fiber optics bundle will pipe the image collected by a quartz lens to a camera unit mounted on the side of the vehicle.

Two cameras will be carried on each vehicle. Each will be coupled to two fiber-optics bundles. Half of the vidicon surface in each camera will carry the view from one bundle, the other half of the surface will carry the view brought in by the second fiber optics bundle.

Fiber optics details—To avoid graininess from the fiber optics in the televised image, there is a plan to rotate each bundle fairly rapidly. A somewhat comparable technique is used in the orbiter rotation of image orthicon tubes to avoid burn-in of hot spots. On the *Saturn*, the fiber-optics bundle will have a synchronous motor drive at each end, so that the bundle rotates with respect to its lens and camera tube. The aim is to move the bundle fast enough for the eye's persistence of vision to fill in the holes that would otherwise appear in the picture.

The two cameras are mounted directly outside the *Saturn's* engine compartment, but their control units that prepare the raw video signal for transmission are located near the top of the first stage. The outputs from these two units pass to a video register that transmits alternate frames from each camera. Each camera receives its synchronization pulses from this unit, which then acts as a gate to hold back every other frame. The resulting composite signal contains four sets of images.

Basically, the television system operates to normal commercial standards, but has increased horizontal resolution. It is a 525-line system, with 30 frames per second and 60 fields per second, standard EIA synchronization. Horizontal resolution is 650 lines and the resulting bandwidth increases to 8 mc, compared to the commercial 4½-mc. Sweep frequency is the standard 15,750 cps.

On the ground the composite signal is split between two video channels, each operating at 15 frames per second. These are fed to monitors with high-retention phosphors, because the scan rate remains at 1/30 of a second per frame.

Versatile system—The cameras, control units and video register are being supplied to Boeing by the electronic instrumentation division of Lear Siegler. Describing the Boeing system, Paul Oeltjenbruns, manager of applications engineering for video systems, pointed out that it was extremely flexible in the way that it could be applied. It is intended for research and development flights of the S-IC, and the areas to be viewed can be varied by changes in the lenses and fiber optics. To watch separation, the camera might be moved to the top of the first stage. If required, a zoom lens can be accommodated.

Lear Siegler has had considerable experience in the development of high-reliability television systems, and the firm's 431 series camera has been in such diversified environments as the search for the lost submarine USS Thresher on the ocean floor and the observations of *Echo* balloon deployment in space. However, the S-IC environment called for a new design of camera, Lear Siegler's Model 0789.

This unit has to operate over a tem perature range of 0-140°F and must b capable of operating after experienc ing temperatures between —40°F an 160°F. It must be able to withstand five-minute acceleration of 20 g in a three axes, or a shock of 30 g. It mus also be able to withstand 16-g rm sinusoidal vibration between 5 and 2,00 cps.

Camera size is 8½ in. overall lengt by 2¾ in. diameter. Vidicon sensitiv surface is ⅜ by ½ in. The camera cor trol unit is 9.12 by 6.31 by 4 in. and th two items together weigh 9.5 lbs.

Transmitter critical—To develop a L-band transmitter with a ruggedne comparable with that of a television sy tem—capable of handling the 8-m wideband output—is a considerab problem in itself. Boeing has selecte Conic Corp. as subcontractor for thi The Model CTM-UHF-4 transmitter d veloped has a 2-watt output into a 5 ohm load and is an all solid-state desig with frequency stabilization by crysta referenced phase-locked loops.

Under a $101,000 contract, fo production units and one qualificati test unit are to be supplied. Operati at a carrier frequency of 1,710 mc, t transmitter has a capability of ±6 n deviation and can carry video signa with frequencies up to 8 mc.

Contained within a cast-aluminu housing with overall dimensions of 5. by 4.62 by 1.31 in., the transmitt weighs 30.7 oz.

Video modulation and power inp leads pass through RFI assemblies th filter to requirements of MIL-1-266C except for antenna-conducted interf ence. A video amplifier accepts the s nal and pre-emphasises it to compe sate for roll-off of the composite vid signal.

The resulting modulation voltage applied to a varicap diode connect across a voltage-controlled oscillat tuned circuit. A 1.4-v peak-to-peak

ut provides a center frequency devia-
ion of 2 mc. After power amplification
nd multiplication by varactor tripler
nd doubler stages, this becomes an out-
ut deviation of 12 mc, linear to within
% of the input modulation.

Amplifier "a breakthrough"—"One
f the breakthroughs in this unit," says
Iugh M. Bennett, president of Conic,
was the broadband power amplifier,
vhich is 16 mc wide and delivers 10-12
vatts." This amplifier operates at 284
nc, delivering the high-power signal to
he varactor multiplers. "The difficulty
hen was getting good efficiency from
he multipliers and still having good
andwidth," Bennett says.

During vertical and horizontal syn-
hronization intervals, the VCO fre-
uency is locked to the reference crystal
requency by means of a subsidiary con-
rol loop. A sample of the power ampli-
er output and the crystal oscillator out-
ut is applied to a mixer circuit. The
utput of this is amplified and applied
o a frequency discriminator circuit that
evelops the automatic frequency-con-
rol voltage for the VCO.

The frequency discriminator oper-
tes only when vertical and horizontal
ynchronization pulses enable it. During
nese intervals the transmitter resisting
requency is held at 1,710 mc ±0.242
nc. It is deviated to a value of 1,716
nc for a maximum white level and to
minimum of 1,704 mc by the negative-
oing sync pulses. ■

GE Sterilization Techniques Promising for Planet Probes

King of Prussia, Pa.—General Electric's Missiles and Space Division is meeting with good results in its attack on potential sources of trouble in electronic and other components which must meet thermal sterilization requirements of planetary probe programs.

Some success has been reported in the development of sterilizable high-shock-resistant batteries, a high-shock-resistant relay transmitter and pyrotechnic devices, and much has been learned about the sterilization effects of digital electronic equipment circuits and components and electronic parts.

Among the candidates for further research this year are the sterilization and testing of an S-band transmitter, further work on other electronic piece parts, and the study of thermal effects on heat-shield and parachute material.

Batteries—One of the prime development problems was identified as a high-energy battery-power source—higher than that available in sterilizable nickle-cadmium batteries.

Design studies for the *Voyager* program indicated that an energy density of 30 watt hours per pound, an 18-month activated life capability and the capability for roughly 30 charge-discharge cycles was necessary. Silver-zinc cells were chosen to meet these requirements.

However, there were three major problem areas before a silver-zinc battery of 30 to 35 watt hours per pound could be achieved. These were 1) the development of a sealable plastic cell case that could withstand the heat and strong alkaline electrolyte, 2) reduction of zinc/zinc salt solubility in the strong alkaline electrolyte, and 3) the development of high-temperature-resistant semi-permeable membrane battery separator material having approximately 1×10^6 pores of 5-angstrom nominal diameter per square inch.

A joint development contract was let to the Eagle Picher Co. by GE, for their plate structure and cell case experience. All membrane separator materials to be evaluated were furnished by GE. According to GE engineers, the nominal eight-ampere-hour cell size used in the development program has produced energy densities of 65 watt hours per pound to an end voltage of 1.00 volt per cell.

Three separate 36-hour exposures to 145°C were carried out, and the energy density has been achieved before and after each cycle. In addition, more than 28 complete discharge and charge cycles have been obtained beyond the thermal exposure.

GE engineers are estimating a two-year lifetime for the battery, based upon extensive charged-stand capability tests. Three batteries are undergoing high shock and life tests after sterilization, to see if they can withstand the proposed program's launch, 10-month transfer to Mars and planetary impact.

Relay transmitter—A lightweight,

Stanford Antenna Used in Pioneer Program

*his 150-ft. dia. dish antenna at Stanford University, Palo Alto, Calif., will communicate
rectly with Stanford experiment aboard NASA's Pioneer 6 spacecraft. Radio signals
ill be sent from the dish to the spacecraft's Stanford receiver. Characteristics of the
ceived signal will be returned in Pioneer telemetry and by hot line from Goldstone,
alif., to Stanford. Changes in signal characteristics in this real-time experiment will
dicate electron density between Pioneer and Earth.*

windows for GEMINI

Optically finishing the windows for the Gemini program has been one of the more challenging assignments we have had at Tinsley Laboratories, Inc. The vehicle ports are fitted with a window set consisting of three individual panels. Each panel is fabricated from VYCOR glass supplied by the Corning Glass Co. The optical specifications cover three major areas. (a) High degree resolution • (b) Extreme surface flatness • (c) Freedom from surface imperfection • Each window must allow a minimum of photographic distortion and maximum light transmission for proposed experiments involving light measurement.

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solid-state VHF transmitter was designed to operate at 136 mc, and designed for high resistance to shock loads and thermal environment. It weighs 4.2 lbs., measures 8x2x4 in., and shows an output of 80 watts at some 50% efficiency operating at 30°C.

When the external temperature was raised to 71°C, power output was decreased to 60 watts at efficiencies near 41%, GE engineers said. They noted that the figures are extremely high for this type of transmitter, and "represent significant breakthroughs" in this area.

Several sterilization cycles have produced no noticeable degradation.

Equipment circuits and components—Another undertaking was to obtain experience in the design of sterilizable digital equipment—and to evaluate the effects of the sterilization environment on materials and assemblies as used in this equipment.

Representative samples of digital and analog circuits fabricated by different packaging techniques—such as cordwood modules, integrated circuits, piece parts, and thin-film hybrid combinations—were chosen. The test cycle includes dry-nitrogen heat sterilization followed by mechanical acceleration, vibration, shock and endurance tests. This study is continuing.

Electronic parts—Effects included in this study were parameter changes due to sterilization cycling, changes in reliability and life characteristics, and changes in drift characteristics.

Several evaluations were conducted, including sterilization cycling with parameter measurements made after each cycle, to obtain parameter change information; comparative step stress testing, to obtain indications of changes in reliability and life characteristics, and comparative stress life testing, to obtain changes in drift characteristics.

Piece parts included carbon composition resistors, metal film resistors, solid tantalum capacitors, mylar capacitors, switching transistors, switching diodes, microminiature metal film resistors ($\frac{1}{20}$ watt) and microminiature ceramic capacitors.

According to GE engineers, it appears that film resistors, mylar capacitors, transistors and diodes change little with sterilization cycling, while parameter changes in composition resistors and solid tantalum capacitors are significant. These changes, however, seem to be highly value-dependent; for example, high values of capacitors and resistors changed more than did low values.

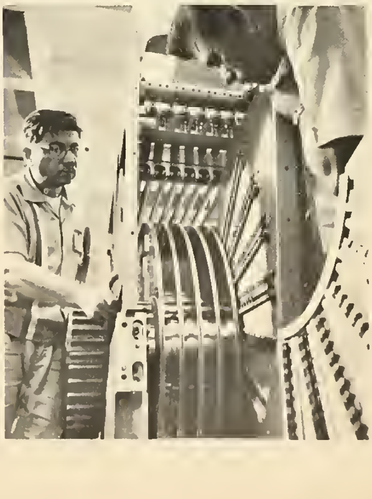
GE engineers also report that effects of sterilization on the life and reliability of microminiature film resistors appears to be negligible, and that comparative step-stress testing would appear to be valuable in determining life and reliability effects.

Pyrotechnics—GE engineers identified a number of potentially applicable explosives that were investigated, firs through a literature search of all commercially available explosives and pyrotechnic devices and then through experimental evaluations.

Those devices which containe acceptable explosives—that is, on th basis of melting point, the 5-second explosion temperature and extrapolate long-time explosion temperature, ga evolution in 48 hours at 100°C and th vacuum stability—were subjected t sterilization. Many were found to b acceptable. ▮

New Product of the Week: Computer Mass Memory

A computer mass-memory with a storage capacity of 200 million bits and a data-transfer rate of up to 42 millio bps has been announced by Librascop Group of General Precision, Inc.



Average access time of the Librafil 3800 is 17 milliseconds. The unit available in a basic 6-disc configuratio and features a fixed head per track, tw methods of search and retrieval and r tractable head plates. It consists of tw main units: a mass memory for dat storage and a controller for interfac control and read-write electronics.

The unit's rotating memory eleme is composed of six aluminum dis coated with a cobalt alloy. The dis measure 38 in. in diameter and 0.5 i thick and rotate at 1,800 rpm. Data stored on both disc faces. Word length flexible. It is available with or witho master-control electronics.

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contracts

AIR FORCE

$4,100,000—**General Electric Co.,** Re-entry Systems Dept., Philadelphia, initial increment to an estimated $40,888,000 contract for research and development on Mark 12 re-entry system.

$3,000,000—**General Telephone & Electronics Corp.,** New York City, initial funding to produce components for electronic security systems to help guard *Minuteman* intercontinental ballistic missile launch sites.

$2,400,000—**Sylvania Electric Products, Inc.,** Waltham, Mass., first segment of a $14,000,000 contract for work on ground electronics equipment for *Minuteman* missiles in Buffalo, N.Y., and Waltham and Needham, Mass.

$1,858,000—**Westinghouse Electric Corp.,** New York City, first segment of a $3,884,100 contract to modify radar equipment in Baltimore.

$1,351,302—**Stewart Stevenson Services,** Houston, first segment of a $2,702,605 contract to make electric power generators.

$1,000,000—**Philco Corp.,** Western Development Lab, Palo Alto, Calif., increment to a contract for work on satellite control network.

$738,300—**Philco Corp.,** Philadelphia, to provide microminiature digital data transmission equipment for use in missile tracking facilities.

$565,000—**Cook Electric Co.,** Tech-Center Div., Morton Grove, Ill., for production of additional airborne direction finding-tracker system units.

$504,254—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Del., to determine the feasibility of using radar reflectors to enhance the penetration of ICBM's.

$245,000—**Boeing Co.,** Aero-Space Div., Seattle, increase in funds for study of transient radiation effects on microelectronics.

$125,000—**Itek Corp.,** Special Equipments Div., Lexington, Mass., to produce five special film viewers.

$98,025—**Union Carbide Corp.,** Linde Div., Indianapolis, for research program on CW plasma arc pumped laser.

$93,251—**Space and Tactical Systems Corp.,** Burlington, Mass., for design of electronic circuitry for solar wind and related experiments.

$90,411—**Cornell Aeronautical Laboratory,** Buffalo, N.Y., for continuation of research on boundary layers in high-temperature flows.

$56,875—**Collins Radio Co.,** Richardson, Tex., to modify the command control installation of Western Test Range.

49,934—**Avco Corp.,** Wilmington, Mass., for Mark 17 re-entry vehicle program updating specifications of program definition phase.

47,100—**Kaman Aircraft Corp.,** Kaman Avi-Dyne Div., Bloomfield, Conn., for a research study of vehicle-guidance-wind-interaction effects on structural design.

ARMY

92,814,791—**Western Electric Co., Inc.,** New York, N.Y., to continue research and development on *Nike X* antimissile system.

10,048,070—**Bendix Corp.,** Detroit, to produce guidance and control components for *Pershing* missiles in Teterboro, N.J.

1,993,427—**Radiation, Inc.,** Melbourne, Fla., for continued work on Mark IV satellite communications terminals.

1,073,272—**Raytheon Co.,** Lexington, Mass., for work on the *Hawk* air defense missile system in Andover, Mass.

NAVY

4,406,018—**Motorola, Inc.,** Scottsdale, Ariz., for continued production of guidance and control systems for *Sidewinder* air-to-air missiles.

4,250,830—**Raytheon Corp.,** Lexington, Mass., modification to firm-fixed-price contract by Bureau of Naval Weapons for guidance and control systems for *Sidewinder* missiles.

60,769—**Space Science Co.,** Falls Church, Va., for manned orbital laboratory program planning.

26,464—**Dayton T. Brown, Inc.,** Bohemia, N.Y., for evaluation and test of prototype models of a prototype remote arming/safing system for air launcher weapons.

NASA

$1,500,000—**Ling-Temco-Vought, Inc.,** Range Systems Div., for final contract negotiation to provide computer support services for the Michoud Assembly Facility, New Orleans, La., where stages of the Moon-mission launch vehicles are being constructed.

$584,916—**Northrop Corp.,** Northrop Space Lab., Huntsville, Ala., from Kennedy Space Center for expansion and revision of the operational intercommunication system on Launch Complex 37B.

$500,000—**International Telephone and Telegraph Corp.,** Fort Wayne, Ind., from Goddard Space Flight Center for photographing the weather patterns of half the Earth.

$500,000—**International Harvester Co.,** San Diego, Calif., four gas turbine generator sets for use at a tracking station in the Mojave Desert.

$295,000—**Computer Control Company, Inc.,** Framingham, Mass., from Marshall Space Flight Center for an input/output system that will collect data from four analog computers.

$264,358—**Hughes Aircraft Co.,** Culver City, Calif., from Flight Research Center for instrument and instrumentation support services.

$245,329—**Scientific Atlanta, Inc.,** Atlanta, from Manned Spacecraft Center for a radar boresight test facility.

$240,000—**North American Aviation, Inc.,** Autonetics Div., Anaheim, Calif., for standard microcircuits for *Saturn* and other advanced space systems.

$100,000—**University of Michigan,** Ann Arbor, to design an orbiting fishnet-like antenna to catch elusive radio signals from deep space.

$91,291—**Astro Research Corp.,** Santa Barbara, Calif., from Western Operations Office for structural design development for large orbiting radio astronomy antennas. Also, $91,142 for study of advanced structural concepts for space applications.

$82,250—**TRW Systems Group,** Redondo Beach, Calif., from Headquarters for investigation of high-speed impact phenomena.

$72,000—**Motorola, Inc.,** Military Electronics, Scottsdale, Ariz., from Manned Spacecraft Center for application of integrated circuits to nondigital portions of the *Apollo* up-data link system.

$69,041—**Symetrics Engineering Corp. of Florida,** Satellite Beach, Fla., from Kennedy Space Center for VHF antenna system.

$48,206—**H. K. Ferguson Co.,** Cleveland, from Lewis Research Center for engineering services for design specifications for propulsion components evaluation facility.

$47,040—**Collins Radio Co.,** Cedar Rapids, Iowa, from Edwards for radio sets.

$34,750—**Martin Co.,** Denver, Colo., from Kennedy Space Center for study of the effect of transporting the mobile service structure on the crawler/transporter at Launch Complex 39.

INDUSTRY

$1,150,000—**Wismer and Becker Contracting Engineers,** Sacramento, Calif., from **General Electric Co.,** Mississippi Test Support Dept. Bay St. Louis, Miss., for installation of technical systems at the NASA's Mississippi test facility.

$1,100,000—**FMC Corp.,** San Jose, Calif., from the **Boeing Co.,** Seattle, for the Air Force *Minuteman* intercontinental ballistic missile program.

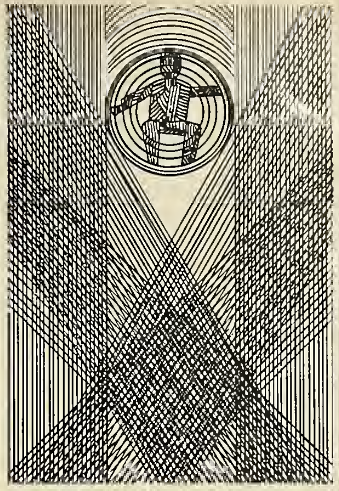
Ling-Temco-Vought, Inc., Dallas, from **Texaco Experiment, Inc.,** Richmond, Va., to evaluate a supersonic inlet system and conduct model testing for a low-volume-ramjet missile. Amount not disclosed.

COMMUNICATIONS SATELLITE CORPORATION

$1,780,000—**International Telephone and Telegraph Corp.,** New York City, for expanded telephone, TV and data transmission service.

MISCELLANEOUS

$100,000,000—**Raytheon Co.,** Lexington, Mass., from Saudi Arabia to supply *Hawk* ground-to-air missiles as part of a $400 million air-defense system.



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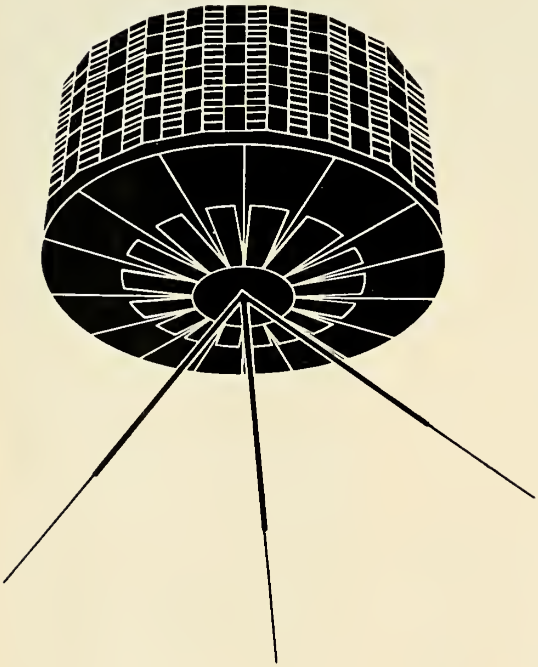
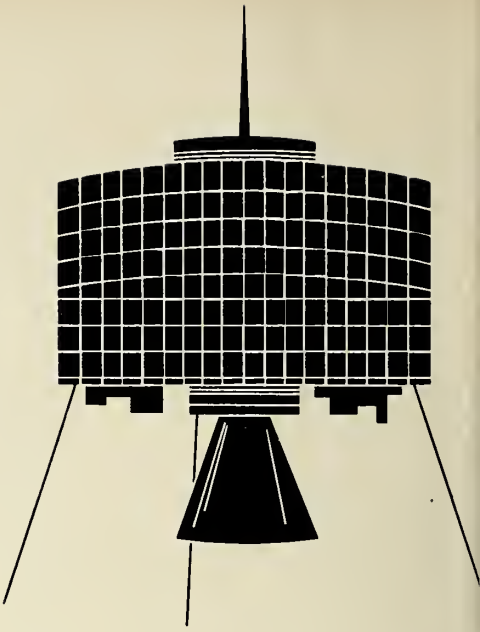
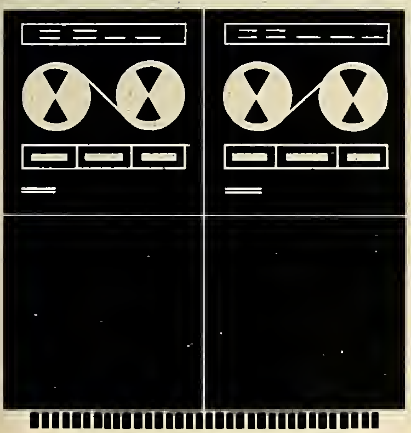
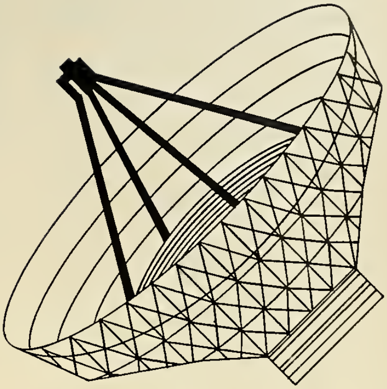




SPACE COMMUNICATIONS





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names in the news

SCHEY

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GRANT

HART

Ralph E. Schey: Elected vice president-treasurer of Clevite Corp. **Kenneth M. Leighton** has been named to succeed Schey as general manager of the Harris Div.

Stewart Pfannstiehl: Elected vice president of Oak Electro/Netics Corp. He will assume corporate assignments, particularly in the areas of marketing and product development.

Alan J. Grant: Appointed executive vice president of Lockheed Electronics Co. He will assist the president in the overall management of the firm's five operating divisions.

F. Donald Hart: Appointed president of Lear Siegler International, S.A. He will be responsible for the overall operation of LSI's foreign subsidiaries.

Joseph Rapone: Elected vice president of manufacturing by the board of directors of Eugene Engineering Co., Inc.

Larry Courtney: Elected 1966 president of the Southern California chapter of the Electronic Representative Association (ERA). He is vice president and general manager of Moxon Electronics Corp.

W. S. Bobier, Jr.: Appointed vice president, research and engineering, at Denison Div., American Brake Shoe Co. In addition to his new responsibilities, he will continue as director of the company's Columbus-based hydrodynamics research center.

Harry F. Rice, Jr.: Appointed executive vice president of A. W. Haydon Co. He was formerly executive vice president of Qualitrol Corp. and president of Micro Control, Inc.

L. Wayne Mullane: Elected chairman of the board of directors of Aerojet Delft Corp. He is a group vice president of Aerojet-General Corp.

Dr. Victor H. Grinich: Appointed technical director of Fairchild Instrumentation, a division of Fairchild Camera and Instrument Corp. He will be responsible for establishing a department to investigate new techniques in measurement, exploring new product directions and instrumentation requirements.

J. Keith Hunton: Appointed senior engineering specialist for microwave devices at the western operation of Sylvania Electronic Systems, a division of Sylvania Electric Products, Inc. He is responsible for the development of advanced microwave devices for electronic warfare and reconnaissance systems.

Kenneth J. Kerr: Joined Itek Corp. as assistant to the company's vice president in charge of government activities. A former Air Force colonel and aerial reconnaissance expert, he will assist in directing and supervising the company's government business operations and activities.

F. Robert Hill: Appointed as chief engineer of anti-submarine warfare programs for the Electronics Div. of General Dynamics Corp. He was formerly assistant general manager of Hazeltine's Electro Acoustic Systems Laboratory, and was one of the original founders of the laboratory.

R. J. Demartini: Appointed group vice president of Huyck Corp., responsible for the company's North American Formex Divisions, succeeding **O. G. Haywood,** who has been elected president and chief executive officer of the company.

Donald A. Schultz: Appointed assistan corporate secretary of Milgo Electroni Corp. He will assume the duties and responsibilities of assistant corporate secretary in addition to his position as manage of the information services department.

Q. T. Wiles: Elected a corporate vic president of TRW, Inc. **J. J. Antalek** wa also elected a corporate vice president.

James V. Crawford: Named group vic president of four Garrett Corp. manufac turing divisions. The following officers wer also promoted to vice president: **Henry W Feil,** controller, to vice president and con troller; **Carl F. Fisher,** treasurer, to vic president and treasurer. Also named wer four new officers: **Richard E. Palmer,** as sistant manager of the AiResearch Div. i Phoenix, will become vice president an manager of Los Angeles AiResearch **Robert L. Daniels,** manager of Garret Supply Div., will become vice presiden and manager of Garrett Supply; **Jack F Wright,** manager of Airsupply Div., wil become vice president and manager of Air supply; and **Mark E. Bradley** assistant t the president, will become vice presiden and assistant to the president.

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY

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JANUARY

Winter Meeting of the National Society of Professional Engineers, Americana Hotel, Miami Beach, Fla., Jan. 5-8.

Incentive Contracting Program, January 1966 Series, sponsored by the National Defense Education Institute, New York City, Jan. 10-14, Los Angeles, Jan. 17-21, Boston, Jan. 24-28.

Briefing on the Department of Defense Item Entry Control Program, sponsored by the Spares Provisioning Panel of the National Security Industrial Association's Maintenance Advisory Committee, Biltmore Hotel, Los Angeles, Jan. 13.

American Chemical Society National Winter Meeting, Phoenix, Ariz., Jan. 16-21.

Society of Plastics Engineers Regional Technology Conference, sponsored by the Cleveland Section, Sheraton-Cleveland Hotel, Cleveland, Jan. 20.

Third Coral Gables Conference on Symmetry Principles at High Energy, sponsored by the University of Miami, Air Force Office of Scientific Research, Atomic Energy Commission, National Aeronautics & Space Administration, National Science Foundation, and Office of Naval Research, University of Miami, Coral Gables, Fla., Jan. 20-22.

Third Aerospace Sciences Meeting, sponsored by the American Institute of Aeronautics & Astronautics, New York City, Jan. 24-26.

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editorial . . .

Across the Sea

PRESIDENT JOHNSON'S PROPOSAL to step up space cooperation with Europe should be welcome on both sides of the Atlantic. The U.S. stands ready to share the benefits and burdens of space exploration with its allies.

The President told West German Chancellor Erhard that he will send a high-level commission to Europe early this year to consult with nations wishing to join the U.S. in "a major endeavor" in space.

While the objective is laudable there is a major stumbling block which must be overcome before such an endeavor becomes reality. The initiative in the effort must come from Europe and, to date, such initiative has been sadly lacking.

Despite the formation of such groups as Eurospace, the European Space Research Organization and European Launcher Development Organization, the European community has not been able to agree on any objective for a space program.

Years of talk about grandiose projects such as *Aerospace Transporter* have led to nothing. No Pan-European program has been put forward which has stirred either government or public enthusiasm. France alone has demonstrated a grasp of the importance of space technology and is pursuing it in a determined national effort.

The other European nations have been content with a minor national program and a minor effort at cooperation in the above-named organizations. There is no "major endeavor" on which Europe can seek U.S. help because there has been no agreement whatever on what Europe can and should do in space exploration.

Despite protests to the contrary, the problem is not a financial one. It has been easy for Europeans to say they cannot afford the expenditures on space made by the United States and the Soviet Union. But the fact is that Europe has a gross national product three-quarters that of the U.S. It is spending only 0.03% of that on space, contrasted with nearly 1% in the U.S.

It will not be enough for the U.S. to offer Europe a project on a platter, such as a solar observatory or a Jupiter probe. As a U.S.-sponsored program, it will have no more attraction in the long run than some of the unsound proposals already put forward by the Europeans themselves.

What Europe must do is define a viable objective of its own, one which can gain widespread support from the people of England, France, Germany and the other members of the community. If the U.S. offer and visit serve as a catalyst to bring such a project into being, all well and good.

Understandably, the Europeans would like a role in manned space exploration. This is what they should have, not because of prestige but because a manned program is what is needed to catch the imagination of the European people.

The problem then is to find a manned project within the financial and technical reach of the European community.

There is, we believe, such a project, one which we have suggested before. To date, neither the U.S. nor the Soviet Union has firm plans for exploration of the Moon after the initial lunar landings. Yet, a scientific study of the Moon certainly is a must if we are to obtain the full benefits of developing the technology to land there.

For the past two years, there has been discussion of a Lunar International Laboratory at the annual International Astronautical Congress. These discussions, in which the Soviet Union and the U.S. have participated along with European representatives, have dealt solely with the scientific aspects of such an undertaking.

THE TIME NOW IS RIPE to take up the question of how LIL is to be financed and developed. Here, to our mind, is the ideal project for a "major endeavor" in space by the Europeans. It has the glamour of a manned project which will arouse the necessary public and political support. Expensive though it might be, it is within the financial capability of Europe in partnership with the U.S., and possibly the Soviet Union.

More important, it is within the technical capabilities of European industry. The know-how in vacuum technology, nuclear powerplants, materials and microelectronics already exists on the other side of the Atlantic. LIL would provide a challenging project to this technology.

The task of designing and developing the laboratory, outlining the desirable scientific experiments and planning the entire project could be left in European hands. The U.S., aside from providing such space know-how as necessary, would act in a support role of supplying the transportation with its *Saturn* boosters and *Apollo* capsules. It would, in effect, be the "railroad" to get men and supplies to a European LIL.

The USSR, if it wished to do so, could act in a similar capacity. As we have said before, this could be done without any necessity for U.S. access to Soviet launch pads, or vice versa, the only realistic approach to any project which might possibly involve both Americans and Russians.

The Europeans rightly are interested in space because of the capability in advanced technology which it provides, a capability which is the underpinning for any industrial nation in today's world. Their access to this technology could be through LIL.

It would be a promising step forward if the Europeans could agree prior to the visit of NASA Administrator James E. Webb and his mission to put forward LIL as their proposal for the "major endeavor" suggested by President Johnson.

The initiative, after all, should come from them, not from us.

William J. Coughlin

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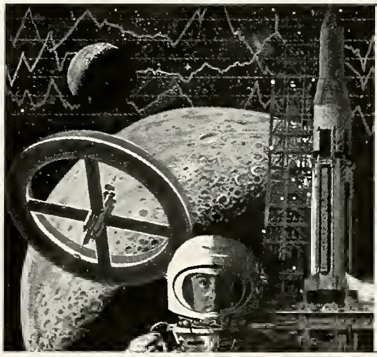

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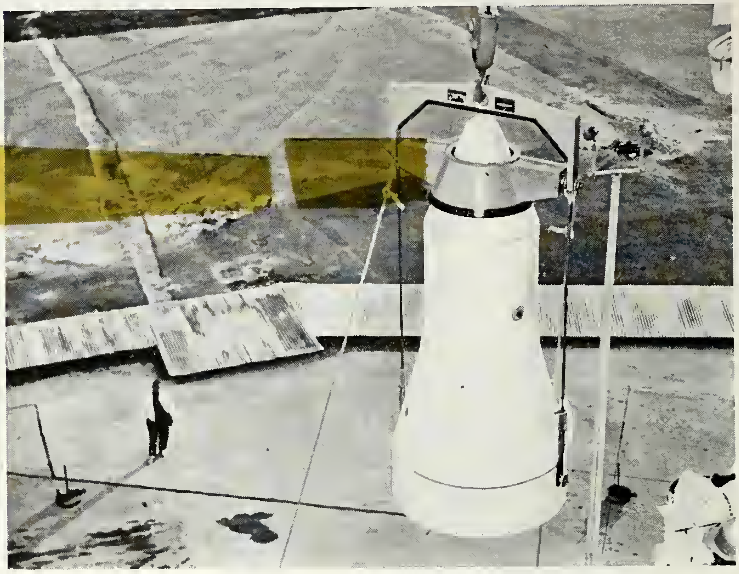

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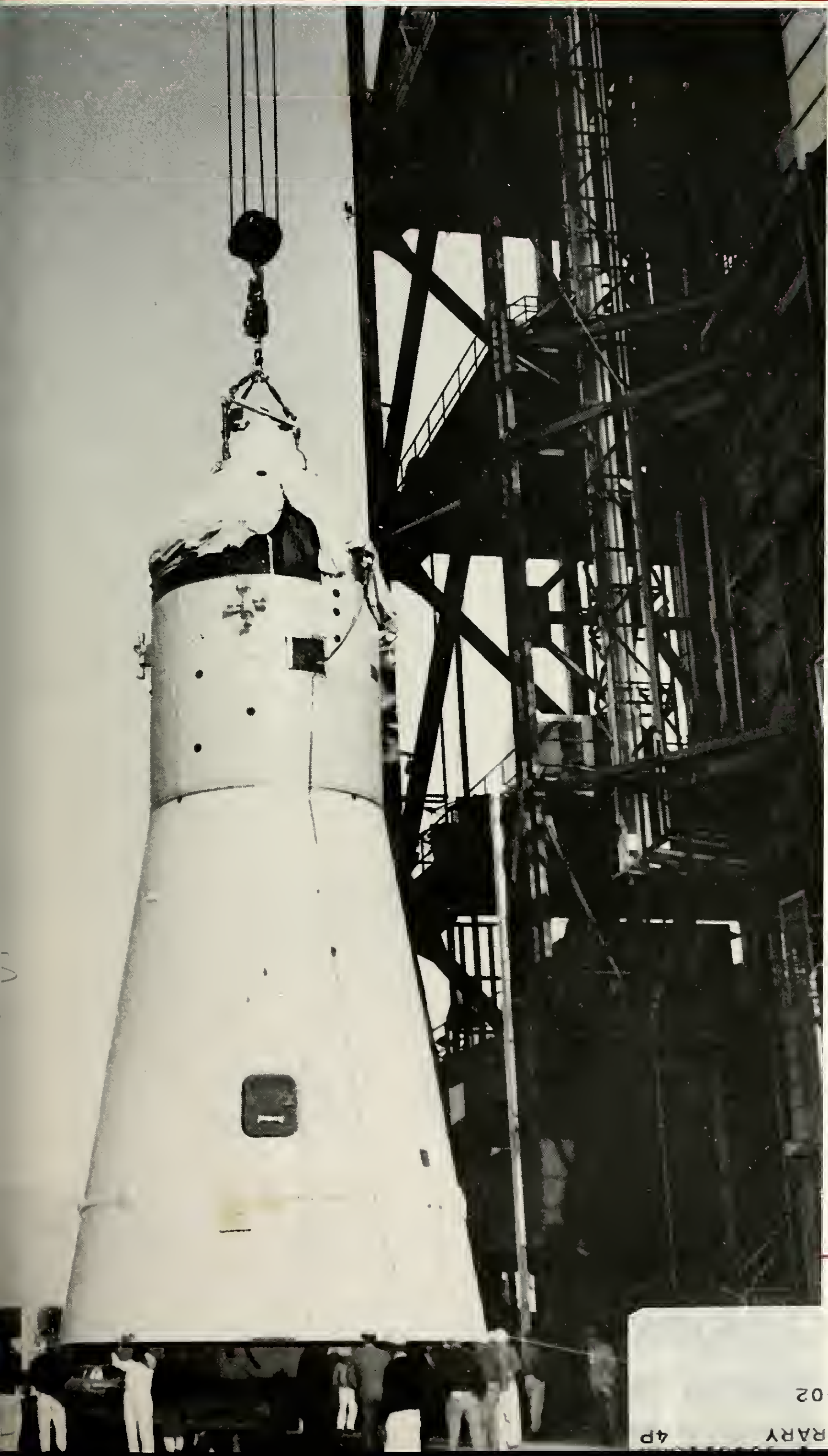

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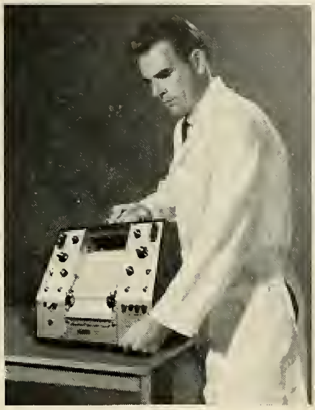

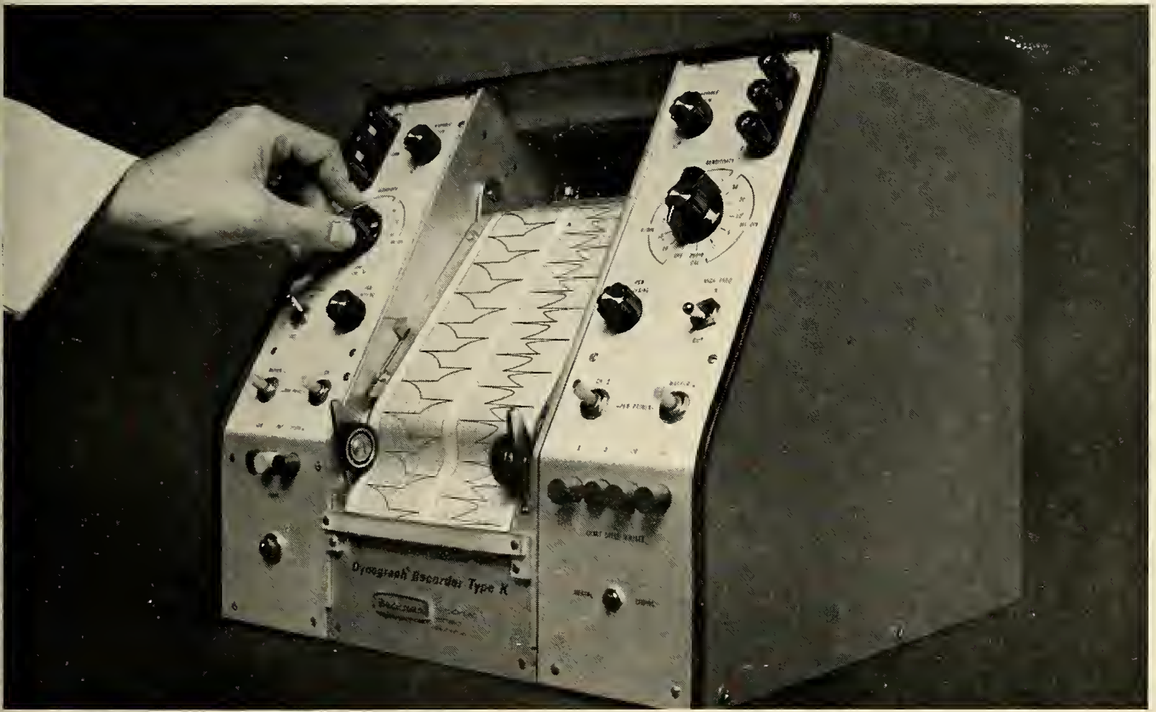

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THE COVER

Apollo 009 spacecraft, first flight-rated model in lunar program, is hoisted to gantry on Pad 24 at Kennedy Space Center. Launch aboard Saturn IB may take place late this month. First four flights of Saturn IB/Apollo scheduled for this year are to orbit 30 scientific payloads.

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letters

Pugwash/Hogwash

To the Editor:

I have just finished reading your Dec. 6 editorial, "Hogwash Conference," and the letter from V. L. Coffield in the Dec. 20 issue. I wish to congratulate you on the editorial, and can't help but wonder which side of the Iron Curtain V. L. Coffield came from.

As one who lived in slavery for almost three and one-half years as a prisoner of war because of the lack of military preparedness before World War II, I am a firm believer in military defense. No power will strike a nation that is adequately prepared with a defense system, has confidence in its ability to win and faith in God.

Apparently, from the defeatist attitude, the brethren who attended the Pugwash Conference have no confidence in themselves and certainly no confidence in America. The fact that they are so willing to surrender to the Communists, thus converting the Free World to slavery, leads me to believe that they have no faith in God.

J. W. Speck
Satellite Beach, Fla.

On the Record

To the Editor:

I am gratified indeed by the accolade from the eight scientists of the Martin Company Research Laboratories (M/R Dec. 13, p. 5). However, credit for the publication of some of my masterpieces rightfully belongs to the excellent editorial staff of M/R for their honest and forthright publication of pertinent subject matter without fear or favor; and in this respect they are performing a tremendous public service by exposing the R&D boondoggling which is increasing our national debt to the extent that the coming generations could conceivably repudiate that debt.

The aforesaid illustrious savants need not wait too long for the printing of a collection of my works; some of my masterpieces have already been documented by publication. To wit, I am the pioneer inventor of push button wireless tuning (p. 765, March 1918 *Electrical Experimenter*), inventor of the method for controlling multiple functions in space-time relationship by means of a single press-button or equivalent (Pat. No. 1,967,-816), inventor of the pulse-time switching basic concept (Claim 4, Pat. No. 1,967,-817). The automatic automobiles in the year 2007 operated by an electromagnetic field through induction from an underground cable, predicted in the book "Russian Science in the 21st Century" published by McGraw-Hill, was invented by me in 1917 (p. 398, Oct. 1917 *Electrical Experimenter*), and the prediction in the same book of knifeless surgery is already described in my biography in Vol. 5, Who's Who in Commerce & Industry, published in 1946, which also documents my basic concept for protection from nuclear explosions that was successfully tested by the U.S. Army in 1955. Furthermore, the basic unifying law of the symmetry in nature, as well as the derivation of our alpha-numerical system from phases of a circle, and the bilateral symmetrical relationship between the sine waveform and the origin of algebra are proved in my essay "God's Circle" (Reg. No. A 93605 Library of Congress). There are many more of my masterpieces.

Incidentally, the river analogy of Heraclitus, a Greek philospher who lived more than 2,400 years ago, anticipated the uncertainty principle of Heisenberg; while his theory of opposites and perpetual changes (in time) portends the harmony of opposites in cyclic phenomena in concept with Pythagoras' theory of measures.

Would the aforesaid Martin Company research savants like to list *their* documented masterpieces? Button, button, who's got the button?

Harry Bricker Fuchs
Farmingdale, N.Y.

Lunar Landing Strip

To the Editor:

How deep is the lunar surface dust?

Since the life of our first man on the Moon may very well depend on the correct answer to this question, why not eliminate this concern altogether?

I propose that NASA send an unmanned rocket, loaded with an epoxy-type liquid, to the Moon and guide it to an impact area situated within the landing capability of our Lunar Excursion Module. Just before impact, the rocket should be exploded, showering the area with tons of its content. The epoxy, upon penetrating the upper layer of the lunar dust, would cure and harden into a solid crust, thus creating a platform for subsequent lunar landing. This resin could be dyed to facilitate visual acquisition by the LEM crew during descent.

Feasibility of such a "crusting" could be checked here on Earth, using ground olivine basalt from the crater Pisgah in the Mojave Desert, to simulate lunar dust. I understand that this material closely resembles lunar rock, and is being used today to test lunar penetrometers.

Cyrille Pouch
Mineola, N.Y.

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Reprints of the editorial index of articles appearing in MISSILES AND ROCKETS during the last six months of 1965 are available at no cost from:

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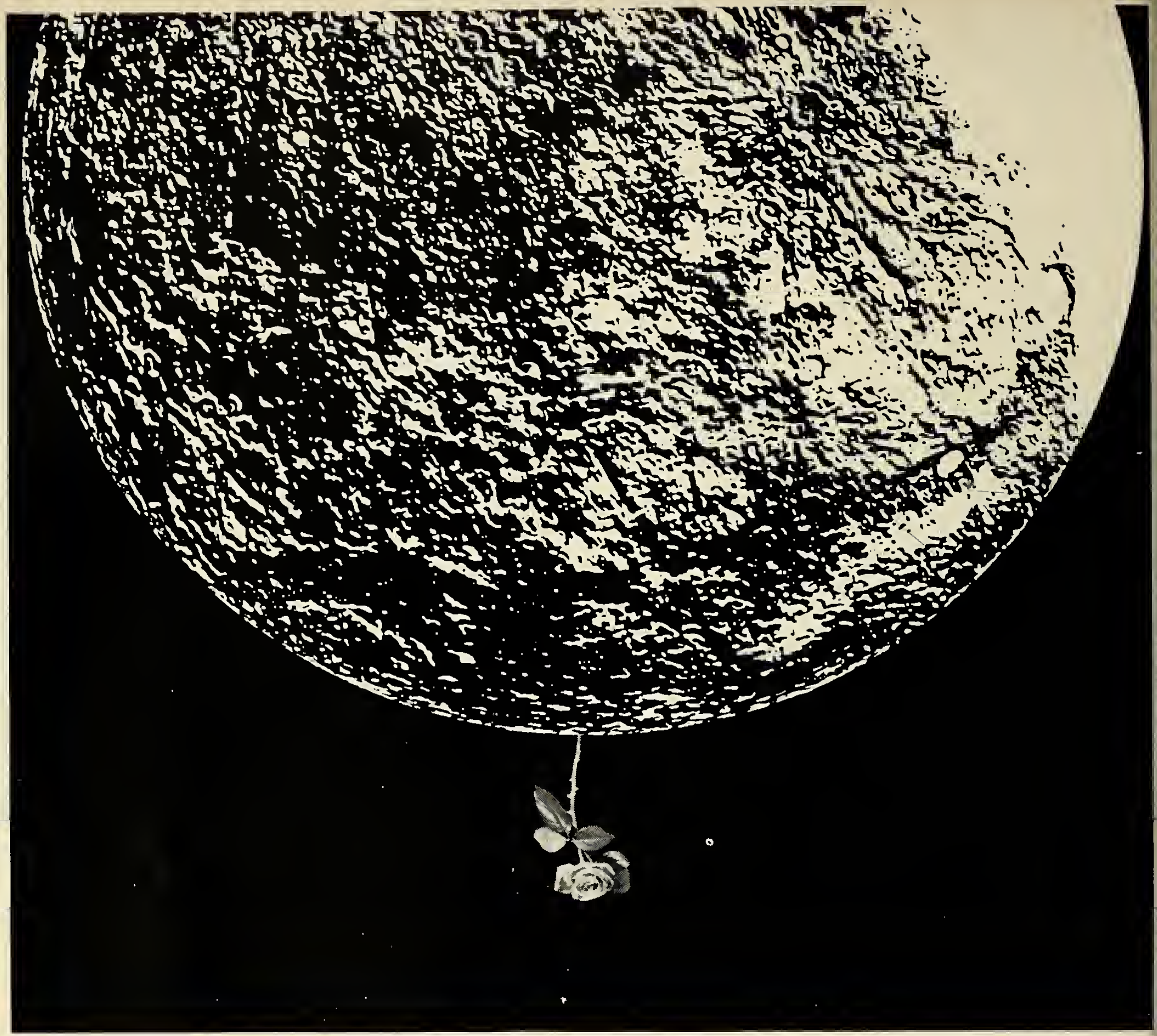

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The Countdown

WASHINGTON

Army To Name Shillelagh Second Source

Army is expected to announce its first buy of *Shillelagh* gun-launched guided missiles from a second production source later this month. Project sources said late last week, however, that the contractor still had not been selected. First buy is expected to be a very small number in comparison with the quantities already being turned out by the *Shillelagh* prime contractor, Philco Corp.'s Aeronutronic Div. (see related story, p. 12).

Big-Solid Funds Are Held Up

NASA still has not been able to obtain release of $4.2 million in FY '66 funds for the 260-in-dia. solid motor development program. Hitch is fate of the program in the FY '67 budget squeeze. If funding for big solids—expected to be about $3 million—is approved by the Administration for the next fiscal year, FY '66 funds are expected to be released.

New Anti-Tank Missile Under Test

Army is testing preliminary design of a third-generation aircraft- or helicopter-mounted anti-tank missile system known as *TETON*. Testing is directed by the Ballistic Research Lab at Aberdeen Proving Ground, Md. Missile is a beam-rider, following infrared radiation directed from a stabilized sight aboard the aircraft. A new infrared guidance system, developed by Aerojet-General Corp. under a $419,000 contract, is being tested by the Army as part of the *TETON* system.

Bright Future Seen for Condor, Shrike

Navy still is evaluating Phase IC definition proposals from North American Aviation and Northrop for the *Condor* air-to-surface stand-off missile. Sources close to the project are optimistic about chances for a development go-ahead in the near future. New production also is seen for *Shrike*, the Navy's anti-radiation homing missile. New units probably will make use of extensive new component developments under way for the past year to correct reliability problems which have kept *Shrike* out of operational service (M/R, Oct. 18, p. 18).

Decision Due on Sergeant Electronics

Army is expected to decide this month on replacement of the computer and all firing electronics of the *Sergeant* ballistic artillery missile. Negotiations now are in progress between Army Missile Command and the prime systems manager for the missile, Sperry Utah. Strong favorite to replace the present computer is one manufactured by Burroughs Corp. for the *Pershing* missile. Main benefit sought by replacement of the electronics is an improvement in reliability.

NASA Scanner Contract Award Expected

NASA is expected to award a feasibility study contract next week on a horizon scanner experiment which ultimately may lead to an *Orbiting Scanner Satellite*. Eight firms are contending: General Electric, General Precision, Honeywell, Lockheed, North American, RCA, Ryan and Westinghouse.

NASA, Navy Sign Oceanology Pact

NASA and Navy have signed an agreement calling for the U.S. Oceanographic Office to conduct studies defining a series of experiments aimed at improving oceanographic and marine technology research from manned orbiting spacecraft. Experiments would be flown as part of the NASA *Apollo* Applications program.

INDUSTRY

Republic Back on MOL Team

Republic Aviation Div. of Fairchild Hiller Corp., one of the original members of the General Electric team which bid on the Air Force *Manned Orbiting Laboratory*, is back on the project. GE, which is responsible for *MOL* experiments, has retained Republic for technical consulting services on planning of the experiments.

Ritland Joins Douglas Space Group

Maj. Gen. Osmond J. Ritland, who retired Dec. 1 as Deputy Commander for Space in the Air Force Systems Command, has joined Douglas Aircraft Co. as special assistant to Charles R. Able, group vice president for Douglas Missile and Space Systems. His first assignment will be to lead a survey team on a review of Douglas launch vehicle test operations at both the Eastern and Western test ranges.

INTERNATIONAL

French Plan Antarctic Launch

France plans to become the first nation to launch a rocket into space from Antarctica. That's the word from the director of French polar expedition organizations. A ramp for the 1967 research launch is being built in French Antarctic territory in Adele Land.

U.S. Seeks to Improve Paris Air Showing

The U.S. government is taking steps to avert a repetition of last year's poor planning job on the Paris Air Show. A Paris Air Show Steering Group including representatives from industry, Dept. of Defense, Dept. of Commerce and the Federal Aviation Agency meets Jan. 10 to begin planning for the 1967 show. State Dept. also called an interagency meeting to discuss complaints about the U.S. performance at the show. That resulted in formation of a committee to be responsible for the overall improvement of U.S. promotional programs overseas and, specifically, a subcommittee to deal exclusively with the Paris Air Show.

Israeli Industry Split into Eight Firms

Israel Aircraft Industries (IAI) is being divided into eight separate companies to concentrate on electronics, aircraft manufacture, engineering, aircraft repairs, fibreglass production, precision instruments, auxiliary airfield and maintenance equipment, and hydraulics. Present management will form an overall organization to handle administrative services. Top management of IAI, which recently became a public corporation, remains under founder A. W. Schwimmer.

AFLC Given New Task

Air Force Logistics Command, Wright-Patterson AFB, Ohio, has been given major responsibility for increasing reliability of operational weapons systems under a new Air Force program.

Present policy emphasizes reliability engineering in the conceptual and development stages. The new program, Increase Reliability Operational Systems (IROS), will focus attention on systems which were operational before the present policy was set up. Examples are the *Titan II* and *Minuteman* missiles.

Prior to 1956, procedure was to design and build a small number of aircraft, flight-test them, redesign when necessary and then order production quantities. Under this system, logistics knowledge was acquired prior to operational use and most design changes were completed before the system was introduced into the inventory.

The present concept combines such steps as design, testing, production and operational use in order to accelerate operational status; logistics managers have accepted the necessity of redesign after systems have gone operational.

Using monthly reports, AFLC's logistics centers will compile failure data and mathematical models to isolate weak links in existing systems. Tests will then determine interrelationships of environment, test equipment, technical orders and design and maintenance skill levels in the problem areas. Where cost effectiveness considerations justify them, component improvement programs will be ordered.

R&D Spending Hearings Set

The first round of Congressional hearings questioning defense and space R&D expenditures were led off by the director of the Bureau of the Budget, Charles L. Schultze, and the President's science advisor, Donald F. Hornig.

Rep. Henry S. Reuss (D-Wis.), chairman of the House government operations research and technical programs subcommittee, has reiterated his intention to question how the decision was reached that 90% of Federal R&D spending is devoted to problems of defense, space and atomic energy. He added that the committee will look into possible ways for improving it, if it is found that "a sluggish rate of advance in civilian technology is the price we are paying for the concentration."

In addition to Schultze and Hornig, other witnesses scheduled for appearance Jan. 7 were William M. Capron, senior staff of The Brookings Institution; Richard R Nelson, economics department of The RAND Corp., and Alvin M. Weinberg, director of Oak Ridge Nationa Laboratory.

HIBEX Launch Shown

The U.S. Army Missile Command has released this first launch photo of the HIBEX booster taken during a recent firing at White Sands Missile Range, N.M. The booster is part of the Advanced Research Project Agency's continuing program of research on ballistic missile defense. The HIBEX program is managed by the Army Missile Command for ARPA. Booster was fabricated by Boeing Co. and loaded by Hercules Powder Co.

Comsat Issues Satellite RFP

Communications Satellite Corp is requesting design study proposals for a multi-purpose communications satellite with a capacity at least 2 times that of *Early Bird.*

Objective is design of a flexibl satellite that could fill various communications functions. The satellite could provide 10 simultaneous television channels, communications between the ground, aircraft and ships and possibly be used for domesti communications.

In related action, Page Communications Engineers was awarded a contract to install a transportabl ground station at Carnarvon, Australia, for the Overseas Telecommunications Commission of Australia.

Navy Begins AA Support

Naval Oceanographic Office i seeking R&D sources to suppor NASA's *Apollo* Applications program.

The program is in support of th space agency's cultural resource program and involves oceanographi application of Earth-orbiting spacecraft, the Navy said. It will includ definition and feasibility phase oriented toward but not limited t AA.

Shot of the Week

The Air Force on Jan. 5 launche a *Minuteman II* from Cape Kenned on a 5,000-mi. flight down the Eastern Test Range.

It was the twelfth straight success for the ICBM.

ITT Gets AEC Award

International Telephone and Telegraph Corp. will provide suppor services at the Atomic Energy Commission's Hanford, Wash., operation under a five-year contract expecte to total more than $75 million.

In connection with the program AEC also signed an agreement wit ITT's Federal Electric Corp. for facility to fabricate and assembl communications, electronics, archi

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Control Systems Engineers
Design, analysis: Thor.

Ground Support Equipment
Design & test ground support equipment. Design electrical systems.

Chemist/Chemical Engineer
Design, develop: Electrochemical, life support devices and pre-treatment techniques for waste fluids.

Chemist—Fuel Cells
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Mathematician
Ph.D. Help make new, special purpose computers/programs.

Battery Technologists
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Shillelagh Buy in Thousands

The Army's gun-launched *Shillelagh* guided missile appears to be well on its way to becoming one of the most mass-produced weapons in the U.S. inventory.

Prime contractor Philco Aeronutronic Div. late last month received a $7.75-million add-on to its initial $20.6-million production contract, a second production award worth more than $71 million (the largest single contract ever awarded to the firm), and a $7.6-million contract to adapt the missile to the U.S./West German main battle tank (MBT) under development.

While exact production quantities of *Shillelagh* are classified, informed sources say that quantities run well into the thousands.

The missile, which uses a 152-mm gun launcher, is to be primary armament on the U.S. Army's General Sheridan armored assault vehicle, the M-60 tank and the MBT.

NASA Sets Up New Office

NASA has established an Office of the Administrator as part of a number of organizational changes.

The new office will include the deputy administrator and staff, the associate administrator and staff and the executive secretariat. Robert C. Seamans, Jr., recently named deputy administrator to succeed the late Hugh L. Dryden, will continue as associate administrator.

The space agency also announced five new posts—an associate administrator and four assistant administrators. Edmond C. Buckley, formerly director of the Office of Tracking and Data Acquisition, has been named associate administrator for tracking and data acquisition. New assistant administrators include William B. Rieke (industry affairs), DeMarquis D. Wyatt (programming), Adm. W. Fred Boone (defense affairs), and John D. Young (administration). They were formerly designated deputy associate administrators.

Clark Millikan Dies

Dr. Clark B. Millikan, director of California Institute of Technology's Graduate Aeronautical Laboratories, died Jan. 2 at the age of 62.

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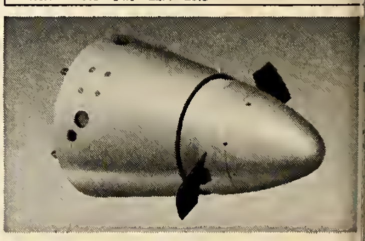

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Millikan, a pioneer in aerodynamics and guided missile research, was chairman of the board of Jet Propulsion Laboratory in Pasadena in its early days. He was awarded the Presidential Medal of Merit for his work in wind tunnel research during World War II and was given the British King's Medal.

NORAD To Reorganize

The North American Air Defense Command and component commands will be reorganized April 1 in keeping with the shifting emphasis of the threat to North America from manned bombers to ballistic missiles.

The realignment also results from overall improvements to the air defense control weapons system and coincides with acquisition of an improved backup intercepter control (BUIC) system.

Under the reorganization, the six numbered NORAD regions will be realigned into four geographically designated ones. City-named NORAD sectors will be redesignated to numbered divisions. Retained will be the Alaskan NORAD region with headquarters at Elmendorf AFB, Alaska, and the northern NORAD region with headquarters at North Bay, Ontario, Canada.

The U.S. Army Air Defense Command (ARADCOM) will also realign its boundaries on April 1. Areas of responsibility of the four regions will conform to boundaries of NORAD regions within the U.S. In addition, the USAF Air Defense Command will establish four numbered air forces to replace the numbered ADC air divisions.

Gen. Branch Dies in Crash

Maj. Gen. Irving L. Branch, commanding general of the Flight Test Center, Edwards AFB, Calif., was killed in an air crash into Puget Sound on Jan. 3.

Branch was enroute to Boeing Field, Renton, Wash., when his Northrop T-38A went down in rainy weather. He was alone in the aircraft.

Canada to Run Churchill Range

The Air Force has transferred management and responsibility of the Churchill Research Range at Fort Churchill, Manitoba, Canada, to the Canadian National Research Council.

The Office of Aerospace Research has managed the range since July, 1962. The U.S. will continue to use the range, which is funded jointly with Canada.

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FY '67 Defense Budget May Remain $60 Billion

REQUEST FOR an additional $12-13 billion in Fiscal Year 1966 to cover the cost of the war in Vietnam does not mean, in the view of Dept. of Defense officials, that the FY '67 DOD budget request will now be less than the $60-billion program which has been anticipated.

Reasoning behind this stems from the fact that the actual annual cost of the war is now tagged at at least $10 billion by both DOD and Congressional observers, and that the FY '67 defense request, if the specific Vietnam costs could be set aside for accounting purposes, would still total about $50 billion.

The DOD caution against assuming that the larger-than-expected FY '66 supplemental request will mean a smaller-than-expected FY '67 budget is viewed suspiciously by some veteran political observers, particularly on the Republican side. It is felt by some that the Administration would like very much to prepare the people and the Congress for a $60-billion budget and then come in with something smaller that will have smoother sailing through the Congress.

It had been widely held that the supplemental would fall in the area of $5-7.5 billion, an assessment mostly based upon refinements of estimates made originally by Sen. John Stennis (D-Miss.), of the Senate Armed Services Committee. Actually, Stennis, along with Sens. Russell (D-Ga.) and Saltonstall (R-Mass.) predicted last August that the cost of the war in Vietnam would hit the $10-billion-a-year level, and that the Administration would have to present the bill for this in January in the form of a second FY '66 supplemental. The Senators made their remarks while openly critical of DOD's failure to submit a bill for the whole figure at that time, rather than just the initial $1.7-billion bill which easily passed.

Separate treatment—As matters now stand, most observers believe the supplemental will go to the Congress during the first week of the session, which begins Jan. 10, and not as a package along with the FY '67 budget, which is still expected to be presented on Jan. 24 or 25. Submission of the supplemental prior to the budget is also apt to drain off some of the attacks Congressmen are certain to make upon the preparedness and fiscal posture of the DOD in connection with the FY '67 budget.

Funds coming from the new supplemental will finance a wide range of DOD projects; however, the largest items are expected to be for conventional munitions, helicopters, and tactical aircraft. The press on munitions manufacturers, accustomed to a much slower pace until this year, is enormous, according to industry spokesmen. Orders are not going to firms other than those who are already in the business and are producing.

As of late last week, DOD officials said that the final version of the FY '67 defense budget still had not been decided. The casualty list because of the rising war costs is, however, expected to include both *Nike-X* and the AF's *Manned Orbiting Laboratory* programs. *Nike-X* has reportedly been stripped of all production money and will continue at the R&D level, and *MOL* funding is now believed to be less than half of that requested by the Air Force. ■

NASA Request Pegged at $5.1-5.2 Billion

THE ADMINISTRATION is expected to approve a Fiscal Year 1967 budget for NASA of over $5.1 billion, but not more than $5.2 billion.

The Administration is also expected to add to its support for the budget request with a special message on the U.S. space program to be presented to Congress shortly after the budget message is sent to Capitol Hill.

The figure of more than $5.1 billion for next year is well below the space agency's request for a $5.6-billion budget, but will be enough to keep the *Apollo* and *Gemini* programs on schedule as well as provide sufficient funding for the new *Apollo* Applications program.

The real cloud hovering over the space agency's plans may be the Congressional reaction to the relatively sizeable space effort in the same period when approval is being sought for billions in additional funding to support the war in Vietnam. Nevertheless, a highly placed Democrat on the House Space Committee predicts that this reaction—despite the fact that 1966 is an election year—will be favorable. He said that while there will be some cuts, they will not be harmful.

Shares—The budget is expected to break down into $3.5 billion for the Office of Manned Space Flight, about $800 million for the Office of Space Sciences and Applications, about $400 million for the Office of Advanced Research and Technology and about $300 million for the Office of Tracking and Data Acquisition.

Informed sources who revealed the size of the NASA budget said that the final total would be between $5.1 and $5.2 billion, but that no final decision had been made. They said discussions between the Bureau of the Budget and the space agency continued last week on several funding requests which could alter the final total.

Start for AA—The $5.1 billion-plus level should provide sufficient funding for the *Apollo* Applications program, perhaps over $100 million. This should supply enough to pay for experiments which will be flown in the program's early missions in 1969-70. The early flights will utilize Command, Service, and Lunar Excursion Modules available from Project *Apollo* after the first U.S. manned lunar landing is achieved.

A request for proposals for Project Definition of payload integration of *Apollo* Applications spacecraft and experiments is expected to be issued by the Marshall Space Flight Center sometime this month. Although first scheduled to be issued early in January, the RFP was delayed because of the failure of NASA Headquarters to approve the AA procurement plan. Space agency officials withheld approval primarily because of the lack of a final decision on next year's budget.

McDonnell Likely Choice for MAW

Development expected to be initiated in FY '67; contract definition phase award imminent; MICOM study to continue

SOURCES CLOSE to the Army program to develop a new *Medium Assault Weapon* (*MAW*) report that the McDonnell Aircraft Corp. version of he weapon has been selected and that a contract definition phase (CDP) award to the firm is imminent.

Development of the new missile, which has already undergone an extensive pre-definition phase test sequence, s expected in Fiscal Year 1967.

The McDonnell system has been involved in a lengthy competition (M/R, May 10, p. 34) with an Army system developed in-house by the Army Missile Command (MICOM), with contractual support in the guidance area.

MAW is being designed to substantially increase the firepower of the individual infantryman against a variety of armored or point targets and is considered as both an offensive and defensive weapon. It is also viewed as part of an Army family of assault weapons and is expected to complement the *TOW* (Tube-Launched, Optically-Tracked, Wire-Guided) heavy assault weapon now under advanced development by Hughes Aircraft Co.

TOW weighs about 160 lbs. and is transported by a three-man team. *MAW* is designed as a shoulder- or bipod-fired missile that will weigh about 30 lbs. and will have a shorter range than *TOW*.

Maximum range of *MAW*, however, will exceed that of any other man-portable anti-tank or assault weapon in the Army inventory. Maximum range is believed to be 1,000-1,500 yards.

The McDonnell version of *MAW* was first called to Army attention through an unsolicited McDonnell proposal. The missile system reflects McDonnell's competitive efforts on behalf of *TOW*, in that *MAW* will also be tube-launched and wire-guided. The Army version of *MAW* also was tube-launched, but the guidance was by a new two-degree-of-freedom free-rotor gyro that responded to initial line-of-sight aiming.

Although the McDonnell system has been selected, Army sources say that part of the CDP effort will include further evaluation of the MICOM system to determine what portions may be used in the McDonnell version.

Both versions of *MAW* use solid fuel propulsion systems. The Army unit has been described as a hypervelocity system.

Both versions also reportedly performed well during test firings. The McDonnell unit is known to have completed a series of at least 13 successful firings. ■

First Launch Photos of Chaparral Released by Army Missile Command

These are the first launch photos of the Chaparral air defense missile released by the Army Missile Command, Redstone Arsenal, Ala. Photos in the sequence were taken during the missile's test program at the Naval Ordnance Test Station, China Lake, Calif. The new mobile system is designed to protect front-line battle areas from all types of aircraft at low to medium altitudes. Chaparral uses Navy-developed Sidewinder IC air-to-air supersonic missiles, adapted for this new ground-to-air role by Aeronutronic Div. of Philco Corp. Missiles are launched from a modified M-45 machine gun mount on which four missiles may be kept ready to fire. For missions requiring full-tracked mobility, a Chaparral fire unit is mounted on an Army M-548 self-propelled vehicle, as shown in this launch sequence (M/R, Oct. 18, p. 18).

Air Force Optimistic About AWACS

Independent funding for radar, system's pacing item, reverses earlier indications that desired performance was out of reach

by Michael Getler

IMPROVEMENTS in airborne radar technology, particularly the ability to detect and track airborne targets over land, have brought about new optimism within the Air Force for successful development and operation of the Airborne Warning and Control Systems (AWACS).

Air Force project officers told MISSILES AND ROCKETS that on the basis of continuing technology studies and surveys, "we now feel we have sufficient technology in hand to meet our needs." They expect to be able to write detailed specifications for the AWACS radar, which has been the pacing item, and move the entire system into the contract definition phase (CDP) in the "later part of FY 1967."

The project to develop an airborne platform from which high-performance targets could be detected at long ranges and in the presence of severe ground clutter got started in FY '65, but was reoriented in FY '66 by the Secretary of Defense. At that point, studies indicated "that the attainment of the hoped-for performance is very unlikely."

In FY '66 the AWACS project was reduced to a $3-million effort. However, because of the basic importance of the problems of overland radar detection, that portion of the project was given an additional $8 million to proceed separately as an advanced technology program.

Air Force spokesmen stress that the program still remains a two-pronged effort, one being development of AWACS as an operating system and the other a long-term radar technology project expected to continue for more than 10 years, independent of the future of AWACS.

System's concept—As presently conceived, the AWACS equipment will be carried aboard one of the three aircraft types now under study. Its primary mission will be to provide a rapid air-battle management capability in support of both Tactical Air Command (TAC) and Air Defense Command (ADC) operations. The system, in effect, will provide early warning, command, and control functions for TAC or ADC, primarily in remote areas where there are little or no existing ground environment facilities. The system would allow airborne control of both TAC and ADC aircraft and ADC missile defense forces.

AWACS is designed to function against "the primary threat" confronting both commands, but the Air Force will not comment upon AWACS' capability vis-a-vis missile detection.

The system is not now intended to operate in support of the Strategic Air Command nor to serve in any primary reconnaissance role.

Last June, three major airframe manufacturers—Boeing, Douglas, and Lockheed—each received Air Force contracts to make "non-competitive" surveys of the technology available for use in AWACS and the adaptation of that equipment into aircraft produced by each manufacturer. The three aircraft under study include the Boeing 707/320B, the Douglas DC-8F, and the Lockheed/Air Force C-141. Results of these surveys are scheduled to be presented to the Air Force Jan. 15.

From this exercise, the Air Force hopes to gather detailed data on equipment and configuration options available, cost estimates and reliability data.

Between this date and late in FY '67, the Air Force hopes to have resolved engineering and equipment integration problems posed by aircraft installation, and to be in a position to write specifications on the radar before commencement of CDP.

Existing equipment stressed—Design of AWACS is proceeding based on use of already available equipment and technology, even in the electronics area. There is no intent to go into further advanced or exploratory development. Air Force sources say radar technology now being considered represents an improvement over both the Air Force APS-95 and Navy APS-96 systems, which have been developed and operated in the past three years.

The aircraft motion-compensation techniques and the signal processing, which is the key to clutter rejection, are both said to be outgrowths of these two earlier radars combined with inputs from other agencies (M/R, May 10, p. 35). Officers say that both rotatable and fixed-array antenna systems will be considered.

AWACS will also carry a general-purpose digital computer, of which the Air Force says several are available to meet the requirements. Analog-to-digital conversion equipment will be used for sensor-derived data.

The AWACS development effort is proceeding under the designation "49AM" and will retain this throughout the development effort. Aeronautical Systems Div. will be the "lead" division in the effort, supported by Electronic Systems Div.

Navy support lacking—While the Air Force now feels it is "in a better position this year" to support development of AWACS, the Navy, which has been wrestling with the problems of high-clutter-environment detection for an even longer period, is still not sure that the technology has advanced far enough to commit to production new versions of early warning aircraft.

Navy suspicion of the radar state of the art has been the primary factor in the past in putting off a decision to build a so-called overland version of the E2A carrier-based warning and control aircraft (M/R, March 29, p. 111).

Navy sources told M/R that in their opinion there still had been "no solid demonstration of this capability."

However, Navy project officers also report that they are encouraged by progress made to date in the APS-111 program, a unilateral, Navy follow-on effort to the APS-96. This radar operates at the same frequencies as the earlier system and uses the same type of mechanically rotatable antenna array, but has improved signal processing capabilities.

The APS-111 project involves Grumman, as E2A prime, General Electric for the electronics, and Dalmo Victor Co. for the antenna. Navy officers say a major assessment of the APS-111 project will be made this May to determine its capabilities and its readiness for engineering development.

Although the APS-111 program reportedly looks encouraging thus far, Navy officers stress that while both the Air Force and Navy have an interest in clutter-rejection techniques, the Air Force problem is more closely identified with direct, overland observation. The APS-111 is said to encompass goals for "better overwater and near-land operation," with "some overland capability." ■

Star-Sighting Difficulties Could Alter Apollo Guidance System

by Jinx Mercer

APOLLO PROGRAM PLANNERS are contemplating a new scientific barrier—astronauts cannot see stars in the daytime.

As a result, they may have to take a second look at *Apollo's* guidance and navigation system.

Although the problem has been noted previously by pilots, it was not until the post-flight debriefing of the *Gemini 7/6* crews that the full impact of starless "day" skies in space was brought home.

All four pilots involved attested that stars cannot be seen in the day side of the sky.

The primary, the secondary, and the "last ditch" manual backup navigation system on board both *Apollo* vehicles rely on stars.

Angular measurements between selected landmarks and navigation stars, *Apollo's* primary navigation technique, is necessary to align the vehicle's inertially referenced platform. Because the platform will be powered down through most of the translunar and trans-Earth stages of flight, it must be brought up and realigned—using the stars—prior to each mid-course correction. This includes the most critical final adjustment, when the Command Module is aligned for its hypervelocity re-entry into the Earth's atmosphere.

Shea confident—Not alarmed is *Apollo* manager Joseph Shea, who says "this is really no problem." He explained that optical equipment consisting primarily of a 28X servo-controlled sextant and a 1X scanning telescope will allow the pilot to find and identify appropriate inertial references even if the crew cannot see stars directly. He did not elaborate, however, as to how magnification would intensify point sources against their background.

The Sun will beam upon the *Apollo* vehicle through most of its lunar mission. Astronauts will encounter "night" only on the back side of the Moon after they leave Earth's orbit.

Astronauts Walter M. Schirra and Thomas E. Stafford reported that there was no difficulty in seeing stars at night. Schirra pointed out that he was able to see such "low-magnitude" stars as the Milky Way and the Sword stars (plus 3 to plus 5 magnitude) in Orion's belt.

Experts in various disciplines are now offering explanations as to why stars are not visible in space while the Sun is anywhere in sight. The source of the trouble, they suggest, could be "dirty" spacecraft windows, natural day-glow layers above the Earth, unnatural glow induced by the spacecraft itself, or solar corona. Some have suggested—rather hesitantly—that it may even be due to a physiological factor.

Window problem—The fact that pilots could see fewer stars from the *Gemini* cockpit than an observer looking up into a clear night sky from Earth has prompted program officials to try to clear up the "window problem."

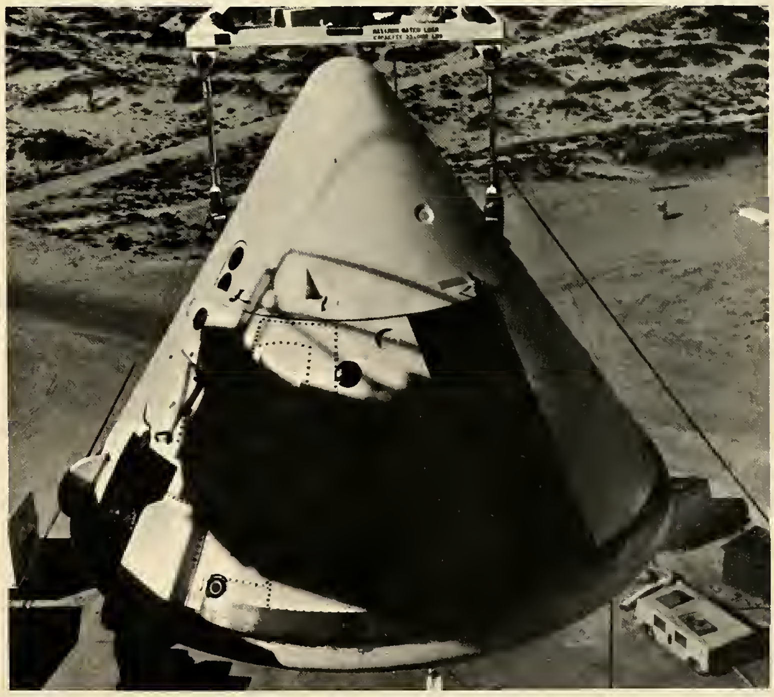
Although nearly all *Mercury* and *Gemini* pilots have complained about "dirty" windows, a thorough investigation was not initiated until after the *Gemini 4* mission. Manned Spacecraft Center investigators concluded that an oily film was being deposited on the windows from material ablating during the boosted phase of flight. (M/R, Aug. 23, pp. 15-16).

As a result, non-metallic ablative covers for the radar, the horizon scanner and other equipment which must be protected from high temperatures during the launch phase of flight were ordered replaced on *Gemini 8* and follow-on *Gemini* spacecraft with non-ablative, re-radiative type materials. The problem appeared to have been resolved.

During the *Gemini 7/6* debriefing, *GT-6* pilots Schirra and Stafford said that the deposit on their window seemed to be more like smoke residue rather than an oily deposit. Stafford pointed out that the deposit followed second staging of the booster, when they were enveloped by "a very large orange flame with brownish-black edging." Momentarily before the staging event, Stafford said he had observed a string of cumulus along the Atlantic range. After the blast he saw a definite change in the window: "the clouds did not look nearly as pure and white as they did before (staging)."

Apollo Readied for Final Abort Test

NASA's Apollo spacecraft #002 is shown being hoisted for mating to its Little Joe II booster at White Sands Missile Range, N.M. The Little Joe will send the spacecraft aloft for what is scheduled to be the final test of the Apollo high-altitude abort system. Launch could take place any time after Jan. 18.



He added: "All of us are of the opinion that the smoke on the windscreens came from the staging event."

Uneven deposits—Photometric readings of the *Gemini 7* windows were made in flight. Dr. S. Q. Duntley of the Visibility Laboratory, University of California, and principal investigator for the visual acuity experiment, told MISSILES AND ROCKETS that light scattering by the deposits was generally about 1.5 times worse on Lovell's window than on Borman's. The measurements were made while the Sun hit the window at a certain angle and the photometer "looked" at a black sky background. It measured the amount of sunlight that was being scattered by the window deposits.

His measurements indicated that the right side of Lovell's window was heavily "speckled" and scattering caused by these spots ranged up to 25 times greater than the clearest area on the left of his window.

Borman's window showed less variation across it. The left side was rather uniform, with no noticeable spots. The right side of Borman's window was unblemished by comparison with pre-flight readings. Dr. Duntley said that Borman favored this portion of the window for most of his sightings.

Despite looking through a portion of window that was relatively clear and recorded light scattering "so barely detectable that it was almost at pre-flight level," Borman said that he was not able to see stars in the day side of the orbit.

Observation penalty—Meanwhile, a scientist whose areas of interest include dim-light phenomena elaborated upon a number of "possibilities" which may account for pilots' inability to see stars in the daytime.

He told M/R that not being able to see stars in the day side of the orbit was an "unexpected" find during *Mercury*, and that the *Gemini 7/6* mission served to really confirm this fact. It becomes a problem, he explained, in that the obscuration—whatever the cause—has reduced daytime observation of stars from the spacecraft by about six magnitudes. (The crew reported being able to sight Venus, now at —4 magnitude, during the day).

He feels, however, that the window deposits may only be partially responsible for the obscuration and not totally to blame. He reasons that if the windows were that dirty, photographs taken of Earth from orbit would appear to be underexposed; this was not the case.

Scientists have concluded that a high day glow may exist at the manned space flight altitudes—and even higher—but until now it has never been thought to be an "intense" day glow that would lower contrast sufficiently to prevent observation of stars. The airglow expert said that high-altitude probes could easily determine the height of such layers, but he raised the following specter: "the spacecraft may be carrying its own atmosphere around with it."

This could be due to shock wave, outgassing material, or a combination of things including cabin oxygen leakage and venting cryogenics, and it is possible that such a phenomenon would also surround a high-altitude probe investigating the height of day-glow layers. He pointed out that a spacecraft moving through rarified atmosphere at 18,500 mph may be creating an ion wake which together with solar radiation might "luminesce."

Finally, the solar corona or the outer envelope of gases surrounding the Sun may actually extend out to or through the Earth's orbit, he said.

"None of these possibilities alone could be responsible for brightness sufficient to obscure the stars," he said. But several or more in combination could be the source of the problem.

Encouragement—It is "encouraging," he said, that unmanned vehicles such as the *Mariner* and other deep space probes moving in the Sun-lighted environment have been successfully oriented and maneuvered by automatic star-tracking systems.

The researcher feels that a low-light photometer should be carried on upcoming *Gemini* missions to measure brightness or luminescence of the background in absolute terms. This could be followed by spectral analyses of the background for scientific value.

Experiments of an immediate nature might include following a star with the photometer from the night side into the day side of the orbit. This would be done through the spacecraft window and then without a window during extravehicular activity. Other tasks might be to photograph (with high-speed film) and to observe a point in the sky where a constellation is known to exist as twilight moves into daylight to determine at which level of background brightness stars of known magnitude disappear. ■

Lunar Exploration Proposals Revealed

SIXTY-FIVE U.S. scientists have recommended a 10-year lunar exploration program to follow the first U.S. lunar landing that calls for three manned flights to the Moon per year through 1979.

Plans for the program were revealed in the reports of six working groups of scientists who met July 19-30 at NASA's 1965 Summer Conference on Lunar Exploration and Science.

Their recommendation calls for two lunar landing missions and one orbital flight each year through 1974, with a similar rate continuing through 1979.

The scientific experiments were proposed for early *Apollo* missions to land men on the Moon for stays up to two days, and *Apollo* Applications lunar orbital and lunar surface missions, post-*Apollo* Applications missions, unmanned lunar orbiter flights and unmanned lunar surface probes.

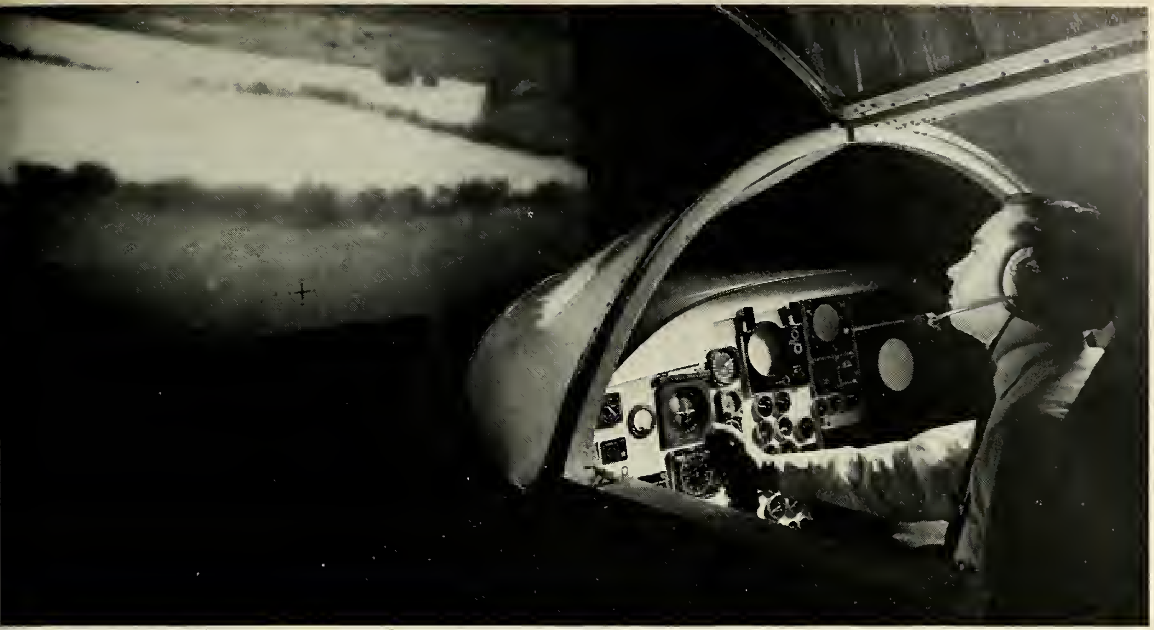
The working groups and the chairman of each group were: geology, Dr. Eugene M. Shoemaker, U.S. Coast and Geodetic Survey; geochemistry, Dr. James Arnold, Scripps Oceanographic Institute; geophysics, Dr. Frank Press, Massachusetts Institute of Technology; particles and fields, Dr. Wilmot Hess, NASA Goddard Space Flight Center; and bioscience, Dr. Melvin Calvin, University of California at Berkeley.

The first priority, for the years following the first manned landing through 1974, will be collecting a variety of lunar material samples. The second priority, the groups said, would be landing the *Apollo* Lunar Surface Experiment Package (ALSEP). The next step would be the addition of astronaut mobility for surface travel.

Equipment which would be needed would include containers weighing no more than 10 lbs., that would be used to keep lunar surface samples sterile and a stereoscopic camera.

Among the experiments suggested for ALSEP are a passive seismograph (weight 25 lbs.), magnetometer and particle detector (13 lbs.), heat-flow measuring device (15 lbs.), active seismograph (7 to 20 lbs.), and an atmosphere measuring device (10 lbs.).

The group told the space agency that to carry out the *Apollo* Applications program—which calls for lunar surface staytimes up to two weeks, and 28-day lunar orbit flights—equipment needed would include automatic position-recording systems to relay data back to Earth, a roving vehicle capable of carrying one or two astronauts and a scientific payload of at least 600 lbs., and a manned lunar flying vehicle able to carry a 300-lb. scientific payload about 10 mi.



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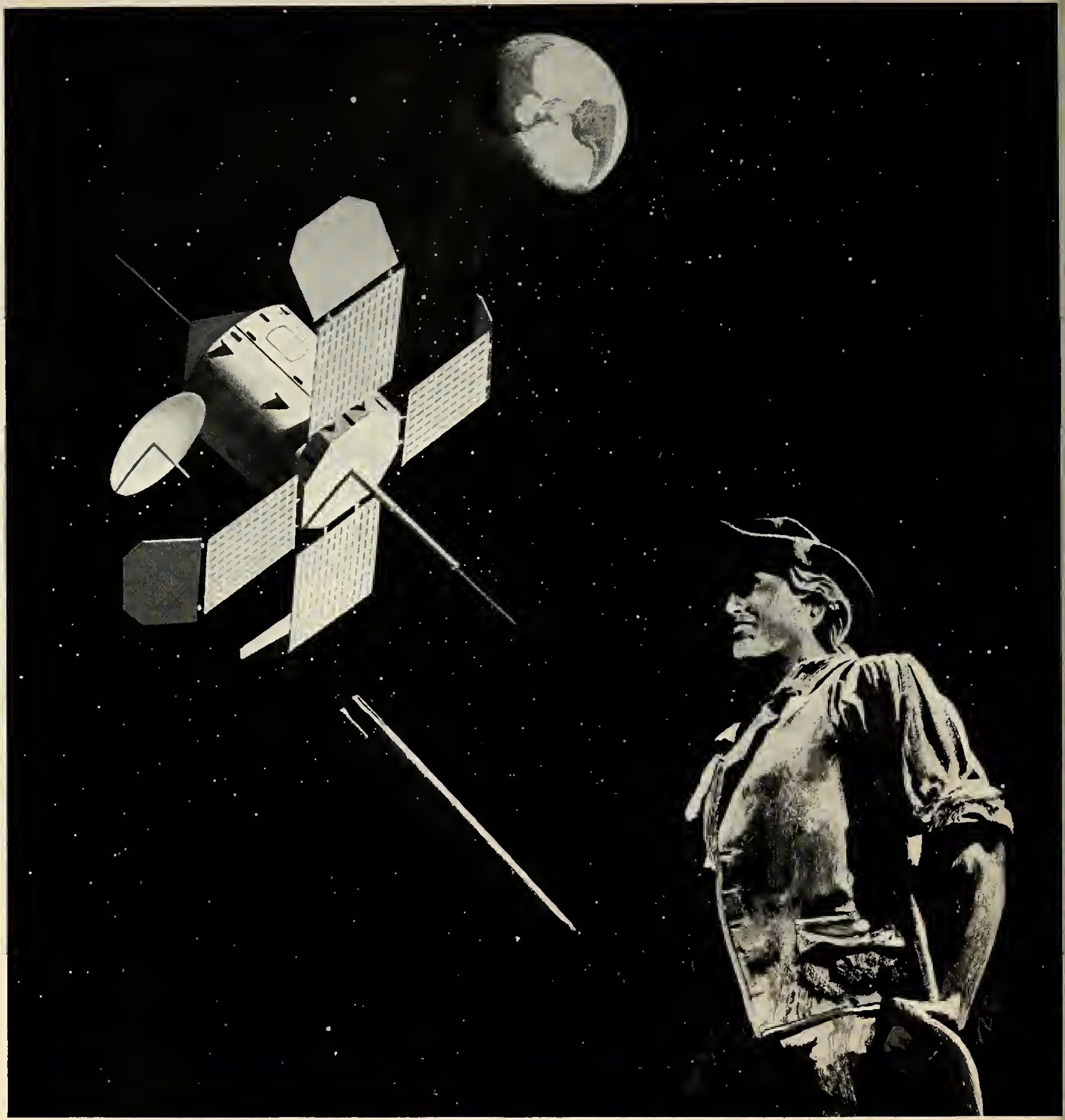

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ASTROLOG

Current Status of U.S. Missile and Space Programs

satellites and spacecraft

ADVANCED ORBITING SOLAR OBSERVATORY (NASA)

Republic, prime. DESCRIPTION: 1,250-lb. spacecraft to make detailed measurements of Sun's radiation; greater pointing accuracy (5 arc sec) than OSO; launch vehicle, THRUST AUGMENTED THOR-AGENA. STATUS: Program cancelled because of tight FY '67 budget; may be resurrected later.

APPLICATIONS TECHNOLOGY SATELLITE (NASA)

Hughes, prime; GE, gradient stabilization. DESCRIPTION: Five-satellite program to test communication and meteorological equipment in medium and synchronous orbit; test bed for gravity gradient communications and meteorological experiments; weight, 780 lbs.; launch vehicle, ATLAS-AGENA. STATUS: Development; first flight scheduled for late 1966.

APOLLO (NASA)

North American, Command & Service modules, systems integration; Grumman, Lunar Excursion Module (LEM); MIT, guidance development; AC Spark Plug, guidance prime; Collins Radio, telecommunications; Honeywell, stabilization & control; AiResearch, environmental control; Northrop-Ventura, parachute recovery; Lockheed Propulsion Co., escape tower rocket; Marquardt, reaction controls; IBM, realtime computer complex; Westinghouse, power conversion equipment. Lunar Excursion Module, prime, Grumman; descent engine, TRW Systems Group; ascent engine, Bell Aerosystems; environmental control, Hamilton Standard; reaction control thruster, Marquardt; guidance, MIT; radar & communications instruments, RCA; TMC, telemetry, Radiation Inc.; fuel cell, Pratt & Whitney; external visual display, Farand Optical; GE, acceptance checkout reliability; rendezvous optical system, Hughes. DESCRIPTION: Three-man spacecraft for Earth-orbital, lunar-orbital and lunar-landing missions. Boosters: SATURN I and SATURN IB for Earth orbits; SATURN V for lunar rendezvous and landing missions; 3-modular spacecraft: Command Module weight, 5-1/2 tons; Service Module, 25 tons; Lunar Excursion Module, 15 tons; total weight, 95,000 lbs. STATUS: First of a series of unmanned orbital tests began with a boilerplate model launch of SA-7, Sept. 18, 1964; LITTLE JOE II unmanned abort test successful, Dec. 8, 1964; first flight-rated spacecraft to be launched January 1966; lunar orbits scheduled 1968; lunar landing by 1970; first manned orbital flight due last half of 1966.

APOLLO APPLICATIONS (NASA)

No contractors named. DESCRIPTION: APOLLO spacecraft would be modified to provide extended life support and battery capability; two tanks would be removed from the Service Module propulsion section to provide room for additional consumable supplies; ascent stage of Lunar Excursion Module for extended operations in lunar orbit and on the lunar surface; many experimental payloads have been proposed, including orbiting telescopes, survey, mapping communications and many others. Boosters: SATURN IB and SATURN V. STATUS: RFP for preliminary program definition for the payload integration work is expected to be issued early in 1966; about 20 flights are planned beginning in late 1968.

ATHENA (Air Force)

Atlantic Research, prime; Honeywell, guidance. DESCRIPTION: 17,500-lb. four-stage re-entry vehicle, attains apogees from 600,000 to 1,000,000 ft.; last two stages drive vehicle and payload earthward at near-ICBM velocities; major diameter, 32 in.; velocity package diameter, 28 in.; length, 51 ft. First-stage engine, Castor XM33 (Thiokol); second stage, either X261 (Thiokol) or X259 (Naval Propellant Plant); third stage, 30KS 8000(Aerojet); fourth stage, Ranger Retro BE3, Hercules. STATUS: Engaged in sub-scale testing of advanced re-entry concepts; 77 launches scheduled; last flight Dec. 10; 13 of last 16 successful; advanced version proposed to AF for 450-lb. payload.

BIOSATELLITE (NASA)

GE, prime. DESCRIPTION: 1,000-lb. satellites to test effects of space environment on plants, animals (primates) and other biological specimens; launch vehicle, THRUST-AUGMENTED DELTA. STATUS: Six flight models to be built; first flight in mid-1966; others to follow at three-month intervals; 14 experiments selected for first flight.

COMSAT CORP. SATELLITE PROGRAM

TRW picked for contract negotiations for advanced worldwide satellite system; spacecraft would have capacity of some 1,200 two-way voice circuits and be launched into either medium-altitude or synchronous orbits; decision on type of system expected six months after contract signing, with delivery of first six satellites 24 months after signing; up to 24 satellites may be bought; launch vehicle not yet selected; Sylvania Electric Products to provide antenna systems at Washington State, Hawaii Earth stations, with delivery to start May 1, 1966; corporation also working on system for use with APOLLO program and commercial communications; Hughes aircraft awarded contract for four synchronous satellites, with two to be orbited probably by late next summer; Page Communications Engineers to provide transportable Earth stations; EARLY BIRD, experimental/operational satellite built by Hughes, launched April 6 and now in synchronous orbit over Atlantic, transmitting between U. S. and Europe.

DISCOVERER (Air Force Program 622A)

Lockheed, prime; GE, re-entry vehicle. DESCRIPTION: THOR-AGENA and ATLAS-AGENA launchings of stabilized satellites; main purpose is to test techniques and components for military space systems. STATUS: All data on program classified as part of DOD information policy; however, indications are that program has been cut back or ended as more economical vehicles have come into use.

ECHO (NASA)

Langley Research Center, prime. DESCRIPTION: ECHO I,135-ft. inflatable sphere in 700- to 805-mi. orbit; passive communication satellite; booster, THOR for ballistic tests; THOR-AGENA for orbital. STATUS: Program complete; ECHO I in orbit since Aug. 12, 1960; two ballistic shots in 1962 unsuccessful; ECHO II launched from Vandenberg Jan. 27, 1964; U.S.-USSR conducting experiments using ECHO.

GEMINI (NASA)

McDonnell, prime; Rocketdyne, spacecraft propulsion; General Electric, fuel cell; IBM, guidance system integration and computer; Honeywell, guidance; Westinghouse, rendezvous radar; AiResearch, environment. DESCRIPTION: Bigger and heavier MERCURY-type capsule to carry two men for up to two weeks; TITAN II used as booster; ATLAS-launched AGENA will be used for rendezvous missions; 15 spacecraft will be produced. STATUS: Development; 12 flights planned; will be used to determine feasibility of rendezvous for lunar mission and long-duration manned flight; first unmanned flight, April, 1964, successful; second unmanned orbital flight, January, 1965, successful; first manned flight successful March 23; second flight successful, June 3-7, 1965, including first extravehicular activity; eight-day GEMINI 5 flight, Aug. 21-29; successful; GT-7 flight, launched Dec. 4, set world record for manned spaceflight duration (14 days); GT-6 launched Dec. 15 after two previous attempts scrubbed; first space rendezvous achieved Dec. 15 during 14-day GEMINI 7 flight when GEMINI 6 on one-day mission came within one foot of sister craft; five more flights planned in 1966; AF participating in program, and will modify GEMINI capsule for MOL.

GEOS (NASA)

Applied Physics Laboratory, prime. DESCRIPTION: 350-lb. geodetic satellite (similar to ANNA) to carry flashing-light beacons, electronic beacons and optical and radar reflectors; launch vehicle, IMPROVED DELTA; 700-900-mi. orbit at a 59-degree inclination. STATUS: First flight launched successfully Nov. 6, 1965; PAGEOS passive satellite developed by Langley Research Center will also be launched first half of 1966.

HYPERSONIC RESEARCH VEHICLE (AF, NASA)

No contractors announced. DESCRIPTION: Manned hypersonic spacecraft capable of Earth-to-orbit-and-return; turbofan, Mach 0-3; ramjet, Mach 3-8 or 10 (oxygen collected and liquefied during this cycle); Mach 8-10 orbital speeds, LH_2-LOX rocket. STATUS: Joint NASA-AF research program approved; NASA funding $5 million in FY '66; AF has advanced technology program in six pertinent areas (mostly engine developments) in FY '65. GE, Pratt & Whitney and Marquardt selected for conceptual and preliminary design of a research engine; engine flight test planned for early 1968.

ICBM ALARM (Formerly MIDAS) (Air Force Program 239A)

Lockheed, prime; Aerojet, IR detector system. DESCRIPTION: Early-warning random-orbit satellite; detect ICBM launchings by IR; two flights conducted in 1963 detected solid and liquid missile launches; satellites are launched piggy-back on various AF boosters. STATUS: Development; no decision on deployment; reportedly competing with over-the-horizon radar; Air Force is currently studying requirements for a new, multi-function satellite, combining the functions of MIDAS and SAMOS.

INTERPLANETARY MONITORING PLATFORM (NASA)

Goddard Space Flight Center, prime; Martin Co. developing nuclear power unit; BTL/Univac, guidance. DESCRIPTION: 131 to 181-lb. satellite launched into cislunar-space orbit with an apogee of more than 100,000 mi.; will measure radiation and solar flare hazards in advance of Project APOLLO; launched by DELTA and THRUST-AUGMENTED DELTA boosters from AMR. STATUS: IMP-I launched in December, 1963; IMP-II launched Oct. 3, 1965; five more satellites are planned, two to be placed in lunar orbit; later flights will use a nuclear power unit as replacement for solar cells; designation, IMP-I is EXPLORER XVIII; IMP-II is EXPLORER XXI.

ISIS (Canada, U.S.)

Canadian Defense Research Board, satellite; NASA, launch vehicle. DESCRIPTION: Three-satellite follow-on program to ALOUETTE to continue ionospheric studies. STATUS: Design of ISIS A began in 1964 with launch planned in 1967; B and C to be launched in 1968, 1969; launch vehicle, THOR-AGENA.

LES (Air Force)

M. I. T. Lincoln Laboratory, prime; consulting support, TRW Systems Group. DESCRIPTION: a series of Lincoln Experimental Satellites carried as TITAN III-A and III-C "bonus" payloads to test military comsat devices and techniques. STATUS: First launch Feb. 11 failed; second, May 6, achieved orbit; LES-3 and 4 launched Dec. 21 are operating but in wrong orbit because of TITAN Control failure.

LUNAR LOGISTICS SYSTEM (NASA)

Studies have been conducted by Grumman, TRW Systems Group and Northrop. DESCRIPTION: Spacecraft to carry support payloads to the Moon. Two designs under study—LEM truck with 7,000-lb. payload and logistics spacecraft with 25,000 to 30,000-lb. payload; booster, SATURN V. STATUS: Program definition of the LEM truck planned in FY '67; program would cost about $1 billion; first step will be to extend lunar stay-time up to two weeks.

LUNAR ORBITER PHOTO CRAFT (NASA)

Boeing, prime; RCA, power and communications; Eastman Kodak, cameras; Marquardt, maneuvering engine. DESCRIPTION: 800-lb. spacecraft launched by ATLAS-AGENA will orbit Moon, taking pictures of lunar surface; radioactive and geodetic measurements will also be taken. STATUS: Five flights scheduled beginning in mid-1966.

MANNED ORBITING LABORATORY (Air Force)

Douglas Aircraft Co., prime; GE, on-board experiments; Aerospace Corp., technical management. DESCRIPTION: Two-man spacecraft to establish military usefulness of man in space; booster, TITAN III-C; GEMINI-X capsule atop 10-ft.-dia., 41-ft.-long canister lab; total weight about 25,000 lbs., orbit below 350 mi.; flights of 30 days in shirt-sleeve environment planned. STATUS: Six-launch program now planned; 30-day missions; 60-90 day missions under study; $150 million in FY '66 funding; unmanned GEMINI canister launch, late 1966 or 1967; manned GEMINI canister launch, 1968; rendezvous and ferry capability possible; Honeywell and Collins Radio reported winners of attitude control and communications subsystems.

MARINER (NASA)

Jet Propulsion Laboratory, prime. DESCRIPTION: 570-lb. unmanned spacecraft for early interplanetary missions to vicinity of Mars and Venus; boosted by ATLAS-AGENA. STATUS: First scheduled Venus fly-by, August, 1962, unsuccessful after booster failure; second passed within 21,594 mi. of Venus, Dec. 14; two Mars fly-by spacecraft launched in November, 1964; first on Nov. 5 failed due to shroud malfunction; MARINER IV launched Nov. 28, flew by Mars July 14, 1965, and transmitted the first closeup photos of the planet; MARINER flight to Venus in mid-1967, and two flights to Mars in 1969 are planned.

MILITARY COMMUNICATIONS SATELLITE (Prog. 369) (AF,DCA,Army)

Aerospace Corp., systems engineering & technical direction; Philco, prime. DESCRIPTION: Multiple-launch, random, active repeater comsat; 24 satellites launched in groups of 8 satellites in 18,300-n.mi. polar orbits; weight about 100 lbs.; TITAN III-C booster. STATUS: Full-scale development as on "interim" system which is to be in operation in 1966. DCA has contracted industry studies on a longer-lived Advanced Communication Satellite system; FY 1968 operational status planned; tactical system also likely.

NATIONAL ORBITING SPACE STATION (NASA, AF)

Many studies awarded. DESCRIPTION: Manned space station with orbital lifetime of one to five years for testing components and techniques in the space environment; weight ranges under study vary from 15,000-20,000 up to 200,000 lbs. STATUS: Decision not expected for two to four years. MANNED ORBITING RESEARCH LABORATORY and LARGE ORBITING RESEARCH LABORATORY being considered.

NIMBUS (NASA)

Goddard Space Flight Center, prime; GE, integration and testing; RCA, vidicon cameras. DESCRIPTION: 900-1,100-lb. second-generation weather satellite; Earth-stabilized polar orbiting; TV cameras and IR scanners in payload; THRUST-AUGMENTED THOR-AGENA B booster. STATUS: First launching successful Aug. 28, 1964; picture & IR quality good in spite of satellite's elliptical orbit; satellite quit transmitting Sept. 23, 1965; second scheduled in 1966, third in 1967 and fourth in 1968-69.

NUCLEAR DETECTION SATELLITES (Formerly Vela) (ARPA)

TRW Systems Group, prime; Los Alamos Scientific Lab/Aerospace Corp., payload. DESCRIPTION: 20-sided, 485-lb. satellite for detection of nuclear explosions in space; 50,000-mi. orbit; booster, ATLAS-AGENA; launched in pairs. STATUS: First pair successfully launched in October, 1963; second pair successfully launched July 17, 1964; three pairs remain; next pair aboard TITAN III-C next fall.

ORBITAL VEHICLE (AF)

Series of vehicles under OAR project to orbit small scientific experiments at low cost; first two satellites, OV1-1 and -3, both failed, first due to separation mechanism in flight and second due to launch vehicle explosion; first flight was first known attempt to launch satellite from an ATLAS-ABRES vehicle on ballistic trajectory; OV2-1, developed by Northrop, also fell victim to faulty Titan III-C Transtage Oct. 15; OV2-3 also failed due to Dec. 21 TITAN III-C Control malfunction; space General at work on OV3; OV-1 was successfully launched Oct. 5 aboard an ATLAS-D.

ORBITING ASTRONOMICAL OBSERVATORY (NASA)

Grumman, prime; Westinghouse, ground station, components; GE, stabilization and control; Kollsman, star trackers; IBM, data processor and storage; Hughes and Avco, communications equipment. DESCRIPTION: 3,600-lb. orbiting astronomical satellite to study ultraviolet spectrum from approximately 1,200 Å to 4,000 Å; four major experiments selected; one piggyback; booster, ATLAS-AGENA D. STATUS: Three flights beginning in early 1966.

ORBITING GEOPHYSICAL OBSERVATORY (NASA)

TRW Systems Group, prime; DESCRIPTION: 1,000-lb. satellite with instruments for geophysical measurements; polar (POGO) and eccentric (EGO) shots planned; can carry more than 20 experiments; ATLAS-AGENA, THRUST-AUGMENTED THOR, booster. STATUS: First launch Sept. 4, 1964, partially successful; 16 of 20 experiments working; OGO II launched Oct. 14, 1965 ceased operation Oct. 24, when electrical power failed.

ORBITING SOLAR OBSERVATORY (NASA)

Ball Brothers, prime. DESCRIPTION: OSO I, 458-lb. orbiting solar observatory; OSO II, 535-lbs.; booster, DELTA; S-16 early version; S-17 and S-57 advanced versions. STATUS: First flight March 7, 1962, highly successful; second flight, Feb. 27, 1965, successful. Third satellite, launched Aug. 25, failed to achieve orbit because of premature third-stage ignition, six more flights planned, with next flight in first half of 1966.

PEGASUS (NASA)

Fairchild Hiller, prime. DESCRIPTION: 3,400-lb. meteoroid-detection satellite employing two 50 x 15 ft. extendable detector wings; Earth orbit 300 to 800 mi.; booster, SATURN I. STATUS: Development; will measure size, energy and frequency of meteoroids to evaluate hazards of impact with manned spacecraft; first launch successful in February; PEGASUS B, May 25, 1965, and PEGASUS C, July 30, 1965, also successful. No more launches planned; formerly known as METEORIOD DETECTION SATELLITE.

PIONEER (NASA)

TRW Systems Group, prime. DESCRIPTION: 130-lb. spin-stabilized solar probe; AUGMENTED DELTA launch vehicle; cylindrical; covered with 10,000 solar cells; four outrigger booms for stabilization; five experiments, 60 to 90-million-mi. communication capability. STATUS: Seven launches in program; first spacecraft launched successfully Dec. 16, 1965; EXTENDED PIONEER under study.

PROJECT SCANNER (NASA)
Honeywell, fabrication and integration; Baird-Atomic, star-mapper telescope; Santa Barbara Research Center, dual radiometers. DESCRIPTION: Unmanned scientific satellite to measure natural radiation gradients of Earth's horizon to determine utility of spacecraft horizon sensors. STATUS: Flights to begin in 1966.

RADIO ASTRONOMY EXPLORER (NASA)
Goddard, prime for first two spacecraft with industry to build remaining four. DESCRIPTION: 270-lb. satellite which will have four 750-ft. extendable antennas to pinpaint radio emissions in space. STATUS: Hardware funding approved in FY '65 & '66 budgets, with first launch by a THRUST-AUGMENTED DELTA in 1967.

RANGER (NASA)
JPL, prime; Hercules, retro-rocket; Northrop, support contractor; RCA, TV system. DESCRIPTION: Before impact, TV cameras take pictures of lunar surface: ATLAS-AGENA B booster. STATUS: RANGER VI launched Jan. 30, 1964; TV system failed; RANGER VII launched July 28, 1964, and impacted Moon after transmitting 4,316 pictures; RANGER VIII launched Feb. 17, 1965, impacted Moon Feb. 20, after transmitting more than 7,000 pictures; RANGER IX launched March 21; struck Moon March 24 after transmitting 5,814 photos; program now complete.

SAMOS (Air Force Program 720A)
Lockheed, prime; photo intelligence equipment, Eastman Kodak; capsules, GE; parachute and guidance recovery equipment, Avco and Northrop Ventura. DESCRIPTION: Reconnaissance satellite; formerly SENTRY; R&D model weighs 4,100 lbs. with E-5 capsule (3,000 lbs. with E-6); booster, ATLAS-AGENA; 100-300-mi. circular polar orbit. STATUS: Operational; advanced SAMOS under development; a successor system, capable of changing orbital plane and altitude on command, is apparently being developed; this newer reconnaissance satellite would have up to six recoverable data capsules or cassettes with lifting-body characteristics, permitting data recovery without returning entire satellite to Earth; could be launched by the TITAN III-B booster now under development; FERRET version used for electronic intelligence and communications eavesdropping.

SATAR (Air Force)
General Dynamics, prime. DESCRIPTION: 300-lb. scientific satellite pod-mounted on side of ATLAS booster; length, 55 in.; diameter 27 in.; 200-lb. payload; orbits vary from 500 to 2,000 n. mi.; as re-entry vehicle, gains speeds up to 30,000 fps; guidance, strap-down system with three orthogonally mounted gyros; unstabilized when in orbit. STATUS: Development; seven vehicles being built under present contract; pods of SATAR type have been flown on 44 missions.

SATELLITE INSPECTOR (Air Force PROGRAM 706)
No contractors announced. DESCRIPTION: Satellite inspection system consisting of a spacecraft capable of co-orbital inspection of non-cooperative satellites. STATUS: Re-oriented from unmanned vehicle to manned satellite using GEMINI; conceptual studies under way.

SECOR (Army)
Cubic Corp., prime, transponder and ground stations; ITT Labs, satellite vehicle. DESCRIPTION: 40-lb. geodetic satellite; rectilinear, measuring 9 x 11 x 14 in.; can be carried piggyback on a variety of boosters; frequency, 162-324 mc for geodetic measurements; 54-216 mc for refraction studies. STATUS: Operational SECOR vehicles 1, 3, 2, 4 and 5 now in orbit. launched in order of mention. SECOR 5, launched Aug. 10, 1965, is the only non-rectilinear satellite in the series, being a 20-in. polished sphere; future SECORS will be rectilinear; expanded program at altitudes of 1,800 mi. is being considered.

SERT (NASA)
RCA, prime. DESCRIPTION: Spinning ballistic test vehicle carrying two electric-propulsion engines for environmental tests. STATUS: First flight July 20, 1964, from Wallops Island, Va., carried a Lewis electron bombardment engine and a Hughes contact ionization engine; the Lewis engine worked well while Hughes engine produced no thrust; follow-on flights cancelled since SERT I proved neutralization of an ion beam in space; SERT III now under study.

START (Air Force)
Award in only one of an expected 10-14 areas has been announced—Martin Co. for work on a vehicle related to the in-house SLV-5; Aerospace Corp., general systems engineering and technical direction. DESCRIPTION: A four-part experimental program, beginning with ASSET, to explore the materials, structures, flight regimes and other areas related to glide atmospheric entry. STATUS: Follow-on phases include PRIME, PILOT, and a high L/D ratio vehicle.

SURVEILLANCE CALIBRATION (Navy)
NRL designed and developed satellites for calibrating ground-based systems; 12 satellites launched to date; Latest Aug. 13; five satellites launched aboard single THOR ABLESTAR to check performance of Navy space surveillance system.

SURVEYOR (NASA)
Hughes, prime; Martin, SNAP device. DESCRIPTION: 2,150-lb. spacecraft for soft-landing 100-300 lbs. of instruments on Moon; nine 2,500-lb. spacecraft are also planned; booster, ATLAS-CENTAUR; SNAP nuclear generator optional. STATUS: First Moon flights May, 1966; seven engineering and three operational spacecraft planned.

SYNCOM (NASA)
Hughes, prime. DESCRIPTION: 24-hr.-orbit instantaneous narrow-band, active-repeater communications satellite; 28 in. in dia. and weighs about 63 lbs.; booster, DELTA; capable of accommodating one full duplex radio telephone channel. STATUS: First launch failed, Feb. 14, 1963; satellite believed to be in orbit but contact lost; SYNCOM II launched July 26, 1963, completely successful; third launch Aug. 19, 1964, successful; satellite positioned in stationary orbit over Pacific; DOD has taken over satellites for military traffic.

SMS (Synchronous Meteorological Satellite) (NASA)
Republic, RCA Astro-Electronics, Hughes, study contracts. DESCRIPTION: 24-hr. weather satellite, Earth-stabilized; TV cameras with variable focus; may use SNAP-50 for power; booster may be ATLAS-AGENA or -CENTAUR. STATUS: Studies to continue; development funds not included in FY '66 budget; ATS and TIROS expected to provide major inputs to the program.

TIROS (NASA, Weather Bureau)
RCA, prime. DESCRIPTION: 285-lb. meteorological satellite; TV pictures of cloud cover; IR sensors to gather heat balance data; one TIROS to be tested for effectiveness in highly elliptical orbit (300-3,000 mi.). STATUS: R&D; 10 satellites launched; all successful; four more launches planned with TIROS wheel configuration (Earth-stabilized) to serve as an interim National Operational System.

TRANSIT (NAVY)
Applied Physics Laboratory, prime; Martin, SNAP device; Westinghouse, shipboard satellite signal receivers. DESCRIPTION: Navigational satellite; R&D model over 250 lbs.; operational, 50 to 100 lbs.; operational system; four satellites in random, near-circular 600-mi. orbits; SNAP nuclear generator; ABLESTAR, SCOUT boosters. STATUS: Four-satellite system operational since July, 1964; system established for use by POLARIS subs and surface ships; two nuclear-powered (SNAP-9A) satellites launched in 1963; NASA studying commercial system.

TRS (Air Force)
TRW Systems Group, prime. DESCRIPTION: 3-lb. scientific satellite to measure radiation; four-sided, measuring 9 in. on a side. STATUS: Operational; first launched piggyback on DOD payload Oct. 17, 1963.

VOYAGER (NASA)
Either Boeing, GE, or TRW Systems Group will be selected for spacecraft program definition in about a year. DESCRIPTION: Unmanned 7,000-11,000-lb. MARINER follow-on spacecraft bus/lander to orbit Mars and eject a capsule to the surface. STATUS: Development expected to begin in late 1966 or early 1967; lander design to be studied in 1967; program definition funded in FY '66; first launch delayed until 1973; spacecraft to be launched by SATURN V, and will be used to explore other planets through 1970's.

X-15 (NASA, AF, NAVY)
North American, prime; Thiokol, propulsion; Sperry Gyroscope, inertial flight data system; Honeywell, adaptive flight control electronics. DESCRIPTION: Manned rocket plane capable of 4,000-mph-plus flight at edge of space; single rocket engine develops 57,000 lbs. thrust. STATUS: Powered flights in progress; unofficial records set—altitude 354,200 ft. and speed 4,104 mph; hypersonic propulsion research program should run through 1968; more than 100 flights have been made; ramjet (X-15A2) flights scheduled for 1968.

space vehicles

ABLESTAR (Air Force)
Space-General, prime; Aerojet, propulsion; Space-General/Bell Telephone, guidance. DESCRIPTION: 2,000-lb. upper stage; 9.5 ft. long; 55 in. dia.; radio command guidance; propellants, UDMH/IRFNA; restart capability. STATUS: Used in TRANSIT and other military programs; THOR booster.

ATLAS-AGENA D (Air Force)
General Dynamics/Convair (ATLAS); Lockheed (AGENA); TRW Systems Group, AGENA B; Honeywell, inertial reference. DESCRIPTION: 275,000-lb. booster; payload capability, 5,000 lbs., in 345-mi. orbit, 750 lbs. to escape; length, 102 ft.; base diameter, 10 ft.; liquid propulsion; modified ATLAS D with 360,000-lb. thrust; AGENA B with 15,000-lb. thrust; restart capability. STATUS: Operational; used in RANGER, DISCOVERER, MILITARY COMSAT, MARINER, LUNAR ORBITER, OAO, SAMOS and other programs. ATLAS Standard Launch

Vehicle developed for AF space programs; ATLAS launches from WTR being used in conjunction with ATHENA launches at Green River, Utah, in an effort to develop scaling laws for re-entry bodies (Advanced Ballistic Re-entry Systems program).

AGENA D (Air Force)
Lockheed, prime; Honeywell, guidance; Bell, propulsion. DESCRIPTION: 1,700-lb. upper stage; 25 ft. long; 5 ft. dia.; all-inertial guidance; propellants, UDMH/IRFNA; multiple re-start capability; ATLAS, THOR and AUGMENTED THOR boosters.. STATUS: Used in DISCOVERER, SAMOS and other military programs as well as a variety of NASA programs; e.g., MARINER, RANGER, OAO and OGO.

CENTAUR (NASA)
Lewis, program management; General Dynamics/Convair, prime; Pratt & Whitney, propulsion; Honeywell, guidance. DESCRIPTION: High-energy upper stage using a pair of RL-10 LOX/liquid hydrogen engines; 30,000 lbs. total thrust; 30 ft. long; 10 ft. dia.; ATLAS D booster; capable of orbiting 8,500 lbs.; 2,300 lbs. to escape; 1,300 lbs. on planetary flights. STATUS: Development; first flight failed; second launch Nov. 27, 1963, successful; third, June 20, 1964, partially successful; fourth flight Dec. 11, 1964, successful; fifth flight Mar. 2 failed when ATLAS-CENTAUR exploded on pad; CENTAUR 6, Aug. 11, 1965, successful; CENTAUR 8 flight scheduled for first quarter 1966 will be first attempt to restart engine in orbit; first SURVEYOR flight also scheduled for second quarter 1966.

DELTA (NASA)
Douglas, prime; Bell Telephone Labs, guidance; Rocketdyne/Aerojet/Allegany Ballistics Laboratory, propulsion. DESCRIPTION: Successor to THOR-ABLE; upper-stage guidance; three-stage vehicle; 800-lb. payload capability in 100-mi. orbit; THRUST-AUGMENTED DELTA payload capability, 1,500-plus lbs. in 100-mi. orbit; THOR missile comprises first stage. STATUS: Launch vehicle for TIROS, EXPLORER, OSO, BIOS, ECHO; TAD used for SYNCOM & PIONEER; 26 previously on order augmented by AF order for 21 more for NASA; THRUST-AUGMENTED DELTA with three solid motor strap-ons also being used.

LITTLE JOE II (NASA)
General Dynamics/Convair, prime. DESCRIPTION: Solid-propelled vehicle with 800,000-lb. thrust; launch vehicles for APOLLO suborbital flights. STATUS: Three launches: Aug. 28, 1963; May 13, 1964; Dec. 8, 1964, successful; May 19, 1965, launch unsuccessful; June 29, 1965 launch successful; last flight scheduled January, 1966.

POST-SATURN V LAUNCH VEHICLE (NASA)
Under study. DESCRIPTION: No firm concept but will be significant improvement over SATURN V (20-30 million-lb.-thrust first-stage large solid motors, and nuclear upper stage under consideration). STATUS: Study to determine characteristics; operational target date post-1975.

ROVER (NASA, AEC)
Los Alamos Scientific Labs, ROVER prime; Aerojet, NERVA prime; Westinghouse, propulsion. DESCRIPTION: First nuclear rocket; tests of Kiwi, prototype of NERVA engine, under way. STATUS: Kiwi tests completed this year; NERVA tests highly successful; full systems tests of engine now set for fall, 1965—12 months ahead of schedule; development of Phoebus reactor initiated; no flight test program funded at present.

SATURN I (NASA)
Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler Corp.; S-IV, Douglas. DESCRIPTION: Two-stage vehicle for early boilerplate tests of APOLLO and PEGASUS; first stage: eight Rocketdyne H-1 engines; second stage: six Pratt & Whitney RL-10-A3 engines; 22,500 lbs. into 345-mi. orbit. STATUS: Four flight tests of first stage successful; all flights with inert upper stage; first flight with live upper stage successfully launched Jan. 27, putting 37,700 lbs. in low Earth orbit; SA-6 May 28, 1964 and SA-7 Sept. 18, 1964, also successful; SA-9 on Feb. 16 put PEGASUS satellite into orbit; SA-8, May 25, and SA-10, July 30, 1965, also successful, completing R&D program.

SATURN IB (NASA)
Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler; S-IVB stage, Douglas. DESCRIPTION: S-1, eight H-1 engines; S-IVB, one J-2 engine; payload capability, 35,000 lbs. in 105-mi. orbit. STATUS: Development; first flight in January or February, 1966; boost APOLLO spacecraft boilerplate models, including lunar landing vehicle; first manned flight in APOLLO program set for October, 1966; advanced version able to orbit 30 tons under consideration.

SATURN V (NASA)
Systems engineering, assembly and guidance, Marshall Space Flight Center; S-IC stage, Boeing; S-II, North American; S-IVB, Douglas; F-1 engine, North American; J-2, North American. DESCRIPTION: S-IC, five F-1 engines; S-11, five J-2 engines; S-IVB, J-2 engine; 140-ton payload in 105-mi. orbit; 95,000 lbs. to escape velocity; 30 tons for planetary missions. STATUS: R&D; first flight scheduled for 1967; prime booster for APOLLO missions; will be used to boost orbiting space station.

SCOUT (NASA)
LTV Aerospace Corp., prime; Honeywell, guidance; Aerojet/Thiokol/Allegany Ballistic Laboratory, propulsion. DESCRIPTION: Solid propulsion four-stage satellite launcher; 72 ft. long; 3.3 ft. dia.; 240-lb. payload in 345-mi. orbit; 80 lbs. to escape. STATUS: Operational; used by NASA for EXPLORER and other small payloads; also procured by NASA for Air Force as BLUE SCOUT.

THOR-ABLESTAR (Air Force)
Douglas, prime; Bell Telephone Labs/Univac, guidance; Rocketdyne, first-stage propulsion; Space-General, second; DESCRIPTION: Two-stage vehicle with 181,900 lbs. total thrust; performance, 900 lbs. in 100-n.-mi. orbit; length, 55.9 ft., diameter, 8 ft., weight, 118,200 lbs., height, 79 ft.; guidance, radio command; STATUS: Operational; used in TRANSIT, GEOS and other military programs.

THOR-AGENA D (Air Force and NASA)
No prime; Douglas, THOR frame; Lockheed, AGENA D; Rocketdyne, propulsion. DESCRIPTION: Liquid-propulsion vehicle to put 1,600-lb. payload in 300-mi. orbit; length, 76 ft.; diameter, 8 ft.; launch weight, 123,000 lbs.; 172,000 lbs. thrust; THOR, radio guidance, AGENA, all-inertial. STATUS: Operational; used in AF space program, TELSTAR, Topside Saunder and other NASA programs; NASA has 11 launches scheduled.

THRUST-AUGMENTED DELTA (NASA)
Douglas, prime; Thiokol, solid propulsion. DESCRIPTION: DELTA launch vehicle with three strap-on solids; performance, 1,000 lbs. to Earth orbit; 150 lbs. to escape; propulsion, three XM-33 solid motors producing 55,000 lbs. thrust each. STATUS: Development; to be used for BIOSATELLITE, PIONEER, SYNCOM, TIROS, COMSAT programs; initial flight Aug. 19, 1964, successful.

THRUST-AUGMENTED THOR (Air Force/NASA)
No prime; Rocketdyne and Thiokol, propulsion. DESCRIPTION: THOR-AGENA with 3 strap-on solids; THOR liquid propulsion, 172,000 lbs. of thrust; each strap-on, 55,000 lbs. thrust; performance, 2,500 lbs. in 100-n.mi. orbit. STATUS: Operational; used for NIMBUS, POGO and other payloads too heavy for THOR, but not heavy enough for ATLAS.

TITAN II (GLV) (NASA)
Aerospace Corp., systems engineering & technical direction; Martin, prime. DESCRIPTION: Manned space booster; Essentially TITAN II with addition of redundant electrical power and flight control systems, malfunction detection system and radio command guidance. STATUS: Development; GT-2 (unmanned version) launched Jan. 19; GT-3 successful on March 23; GT-4, June 3, and GT-5, Aug. 21, also successful, as were GT-7 Dec. 4 and GT-6 Dec. 15.

TITAN III (Air Force Program 624A)
Aerospace Corp., systems engineering & technical direction; Martin, systems integration; United Technology, large solid boosters; Martin, TITAN II portion; Aerojet-General, liquid engines (Transtage); Martin, standardized upper stage; AC Spark Plug, guidance. DESCRIPTION: Quick-reaction vehicle for military space missions; will be used to boost MOL/GEMINI-X; Zero stage, two 120-in. solid motors; first and second stages, TITAN II (storable propellants); third-stage is liquid Transtage; modified TITAN II guidance; payload, 25,000 lbs. in 100-n.mi. orbit, 2,100 lbs. to 22,300-mi. orbit; 5,000 lbs. to escape; STATUS: Development; first flight Sept. 1, 1964 (T-IIIA) achieved primary and secondary objectives, but failed to achieve orbit; second flight (T-IIIA) successful Dec. 10, 1964; first full TITAN III-C flight successful June 18, 1965; second flight Oct. 15, successful launch followed by partial Transtage failure; third launch Dec. 21 also had partial control failure; eight remaining III-C R&D flights; next three for IDSCP; development stretchout moves operational date to June, 1967; a non-man-rated version—TITAN III-B—being studied as more cost-effective booster for satellite launches; uses first two TITAN III-A stages and an AGENA upper stage; first launch, mid-1966; 24 vehicles planned as initial buy; 7-segment version of III-C expected to boost MOL.

missiles

ADVANCED SURFACE MISSILE SYSTEM (Navy)
Raytheon, Boeing, Sperry Rand, General Electric, Westinghouse, RCA & Hughes, pre-program definition contracts. DESCRIPTION: Fleet air-defense weapon for the 1970 time period; to have capability against aircraft and certain types of air-to-surface missiles; will replace the 3-T systems currently in the fleet. STATUS: Pre-program definition; further definition contracts expected before any development decision; commonality with Army's SAM-D has been studied; and Navy to participate in SAM-D development.

ALFA (RUR-4) (Navy)

Navy, prime; Avco, frame; Naval Propellant Plant, propulsion. DESCRIPTION: ASW, surface-to-underwater; weight, 500 lbs.; solid propulsion; H.E. depth charge; range, 1,000 yds.; guidance, free-flight. STATUS: Operational; deployed on destroyers and cruisers; being replaced by ASROC.

ANTI-SATELLITE WEAPON (Army/Air Force)

Boeing, AF program; Hughes, terminal guidance (IR), AF program; Douglas, THOR and ZEUS vehicles and support services; A. D. Little, operations analysis. DESCRIPTION: Consists of both NIKE-ZEUS and THOR-AGENA w/terminal stage programs; intercepts have been accomplished at "hundreds of miles," according to Secretary McNamara. STATUS: Operational, according to DOD.

ARM I (Navy)

No contractor announced. DESCRIPTION: Longer-range, smaller anti-radiation missile than SHRIKE for armament of F-111B and A-7A aircraft. STATUS: Advanced component development; decision on contract definition expected next year.

ASROC (RUR-5A) (Navy)

Honeywell, prime; Sangamo Electric, sonar; GE, torpedo; Libroscope-General Precision, fire control. DESCRIPTION: ASW, surface-to-underwater; weight, 1,000 lbs.; solid propulsion; warhead, nuclear or conventional torpedo; range between 1,800 yds. and 8 mi.; guidance, unguided. STATUS: Operational on DE, DD, DLG, & heavy cruisers; one "live" weapon fired in 1962 Pacific nuclear tests; extended-range version in pre-program definition phase; version adaptable to TERRIER launchers being developed; FY 1966 procurement to complete Navy's stock needs.

BOMARC B (AIM-10B) (Air Force)

Boeing, prime; General Precision Aerospace/Westinghouse/IBM, guidance; Thiokol/Marquardt, propulsion. DESCRIPTION: Surface-to-air; weight, 16,000 lbs.; solid booster/ramjet propulsion; warhead, nuclear; range, more than 400 n.mi.; guidance, command via SAGE; speed, Mach 2.7. STATUS: Three bases operational; production completed; the 188 B models will be distributed among the eight bases after the A model is phased out; all A missiles at five bases operational in northeastern U.S. phased out by the end of FY 1965.

BULLPUP (AGM-12 B & C) (Navy-Air Force)

Martin, systems cognizance; Maxson Electronics Co., production; Thiokol, liquid and solid propulsion; Naval Propellant Plant, solid propulsion (motor loading). DESCRIPTION: Air-to-surface, range, 3-6 mi.; guidance (visual reference), radio-link command. BULLPUP A: Solid propulsion; warhead, 250-lb. H.E. BULLPUP B&C: pre-packaged liquid motor; warhead, 750-lb. H.E. STATUS: BULLPUP A deployed with Atlantic and Pacific Fleets; operational with U.S. Air Force & NATO units; training version (ATM-12) being procured by both services; being produced in Europe for NATO. Planned procurement of BULLPUP B cancelled in FY 1966.

CHAPARRAL (Army)

A surface-to-air adaptation of the Navy's air-to-air SIDEWINDER; mounted on vehicles, in a 4- or 6-missile configuration. Philco's Aeronutronic Div. is prime; CHAPARRAL will be an interim, fair-weather-only, solution to forward-area air defense; has been successfully fired; production award expected soon. (See: SIDEWINDER.)

CLOSE-SUPPORT ASSAULT WEAPON (Navy)

Navy Bureau of Weapons and Johns Hopkins Applied Physics Lab, prime; United Aircraft Norden Div., guidance. DESCRIPTION: Ship-to-shore; outside dimensions compatible with TERRIER shipboard installations; solid propulsion; warhead, H.E.; range, 30 mi. minimum; guidance, inertial and terminal. STATUS: Carried as a line item in FY '66 budget; gyro packages for flight test delivered by Norden; funding dependent on results of guidance system flight tests at WSMR aboard SERGEANT missiles in July.

CONDOR (AGM-53) (Navy)

In-house project, Naval Ordnance Test Station; North American Aviation, Columbus Div. and Northrop Norair Div. completed PDP studies. DESCRIPTION: Air-to-surface TV-guided, stand-off weapon; configuration classified; range, 40 mi. STATUS: Development; intended for use with Navy version of F-111 and on A-6 aircraft; decision on development expected in next few months.

DAVY CROCKETT (M-388) (Army)

In-house project directed by Army Weapons Command at Rock Island, Ill. DESCRIPTION: Surface-to-surface; solid propulsion, bazooka-launched; warhead, sub-kiloton nuclear; guidance, free flight; two launchers—vehicle-mounted or carried by two men. STATUS: Operational in Europe; $13 million provided in FY '64 budget; three per ROAD battalion.

ENTAC (MGM-32A) (Army)

Nord Aviation, prime. DESCRIPTION: Anti-tank; weight, 37 lbs. with launcher; solid propulsion; warhead, shaped-charge H.E.; range, 6,600 ft.; guidance, wire-guided; man-portable. STATUS: Operational; procurement complete; will be replaced by TOW.

FALCON (AIM-4A, C, E, F/26A/47A) (Air Force)

Hughes, prime; Hughes, guidance; Thiokol, AIM-4/26 propulsion; Lockheed Propulsion, AIM-47 propulsion. DESCRIPTION: Air-to-air; weight (AIM-4/47), more than 100 lbs. — (AIM-26), more than 200 lbs.; range 5 n.mi.; supersonic; solid propulsion; warhead, H.E. (except for AIM-26B, which carries nuclear warhead); AIM-4A, and 4E, active radar homing guidance; AIM-4C, and 4F, IR homing; AIM-26 model has nuclear warhead and hybrid IR radar homing. STATUS: Operational buy-out of 4E, 4F and 26 in FY '62; AIM-47 is the armament for YF-12A (A-11); several versions operational on F-101, F-102 and F-106.

GENIE (AIR-2A) (Air Force)

Douglas, prime; Aerojet-General, propulsion. DESCRIPTION: Air-to-air; weight 800 lbs.; unguided; solid propulsion; warhead, nuclear; range, 6 n.mi.; guidance, free flight; supersonic; proximity fuzing. STATUS: Procurement complete; operational on F-101B and F-106; improved version cancelled; launcher being developed by McDonnell for adaptation to F-4 aircraft.

HAWK (MIM-23A) (Army)

Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion. DESCRIPTION: Surface-to-air; weight, 1,275 lbs.; solid propulsion; warhead, H.E.; range, 22 mi.; guidance, semi-active radar homing; 100-45,000-ft. ceiling; provides defense against medium and low-flying aircraft and cruise-type missiles. STATUS: Operational, deployed in Europe, Panama, Okinawa, South Vietnam, U.S. (13 battalions); bought by Sweden and Israel; R&D being conducted to adapt selected HAWK units to an anti-tactical ballistic missile; NATO producing; Japan also plans buy; $34 million requested for equipment and $8 million for spares in FY '66; no further procurement in FY '66; $11 million improvement program aimed at limited anti-missile capability; self-propelled version also under development; large-scale buy by Saudi Arabia; sales to other Arab nations expected.

HIBEX (ARPA/Army)

Boeing, prime; Hercules and Aerojet, propulsion. DESCRIPTION: Experimental program in high-energy propellants; cone-shaped missile; performance classified; solid propulsion. STATUS: Development; accelerations of 800 to 1,000 g's goal; static test of motor successful November, 1964; flight test program of 10 vehicles being conducted at WSMR; third successful flight Oct. 28 was first from underground cell at WSMR; Up-Stage program started to add second stage and increase range.

HONEST JOHN (MGR-1A) (Army)

Douglas/Emerson Electric, prime; Hercules, propulsion. DESCRIPTION: Surface-to-surface; weight, 5,900 lbs.; single-stage solid propulsion; warhead, nuclear; range, 12 mi. (M-31), 20 mi. (M-50); unguided. STATUS: Operational; M-50 being deployed in Europe; to be replaced by LANCE; procurement complete.

HORNET (ZAGM-64A) (Air Force)

(Formerly known as ATGAR). Concept based on North American Aviation Columbus Div. unsolicited proposal, funded by AF. DESCRIPTION: Air-launched, anti-tank weapon, electro-optical guidance. STATUS: pre-development, AF procuring missiles for test at Eglin AFB; Army interested in potential use on helicopters; HORNET also used as demonstration vehicle for new NAA TV-guidance system for MAVERICK (AGM-65A), a new tactical air-to-surface missile for which the AF has asked for DOD approval.

HOUND DOG (AGM-28) (Air Force)

North American, prime; Autonetics, guidance; Pratt & Whitney, propulsion. DESCRIPTION: Air-breathing air-to-surface standoff missile; weight, 9,600 lbs.; turbojet propulsion; warhead, nuclear; range, about 600 n.mi.; guidance, all-inertial; ceiling in excess of 50,000 ft.; Mach 2+. STATUS: Operational; to be launched from B-52G intercontinental bombers; procurement complete.

LANCE (XMGM-52A) (Army)

LTV Aerospace, prime; Systron-Donner, guidance. DESCRIPTION: Highly mobile general-purpose missile; very light weight; pre-packaged storable liquid propellant; warhead, nuclear and H.E.; range, 3-30 mi.; guidance, Automet inertial, one missile per launcher. STATUS: Large-scale development. Tenth flight test, Oct. 10, 1965, from operational launcher; production decision depends on success of current flight tests; eventually will replace HONEST JOHN and LACROSSE and perhaps LITTLE JOHN; division support weapon; to use multi-system test equipment; Navy also studying shipboard version.

LITTLE JOHN (MGR-3A) (Army)

Emerson Electric, prime; Hercules Powder, propulsion. DESCRIPTION: Surface-to-surface; weight, 800 lbs.; solid propulsion; warhead, nuclear; range, 10 mi.; unguided; supplements medium and heavy artillery in airborne divisions and air-transportable commands. STATUS: Two battalions activated in 1961; each equipped with four launchers; air- and helicopter-transportable; may be replaced by LANCE.

MACE (MGM-13A, CGM-13B) (Air Force)

Martin, prime; Goodyear/AC Spark Plug, guidance, Thiokol/Allison, propulsion. DESCRIPTION: Air-breathing surface-to-surface; weight, 18,000 lbs.; turbojet and solid propulsion; warhead, nuclear and H.E.; range, over 650 n.mi. (Model A), over 1,200 n.mi. (Model B); guidance, map-matching (A), inertial (B). STATUS: Five MACE-A and one MACE-B squadrons (in hard sites) deployed in Europe; two MACE-B squadrons on Okinawa in hard sites.

MAW (Army)

McDonnell Aircraft Corp. and Army Missile Command, development of competitive approaches to Medium Anti-Tank/Assault Weapon requirement; Ford Instrument Co., gyro package for Army version. DESCRIPTION: Surface-to-surface; solid propellant; range, 500-1,500 yds.; shoulder-fired; McDonnell version wire-guided; Army version two-degree-of-freedom, free rotor gyro. STATUS: Exploratory development; competitive approaches have been fired against each other, using a ZUNI test vehicle; the best system will be allowed to proceed into full-scale development when evaluation is complete; MAC version completed test series with all 13 firings successful; AMC version fired successfully Oct. 20 using GPI guidance system.

MINUTEMAN (LGM-30) (Air Force)

TRW Systems Group, systems engineering and technical direction; Boeing, major contractor; Autonetics, guidance, Thiokol, first-stage propulsion; Aerojet, second-stage propulsion; Hercules, third-stage propulsion; Avco, re-entry vehicle; GE, MARK 12 re-entry vehicle, MINUTEMAN II. DESCRIPTION: 2nd-generation ICBM; weight, over 65,000 lbs.; solid propulsion; warhead, nuclear; 3 stages; range, 7,000 mi.; guidance, all-inertial, target selected in seconds; 32-sec. reaction time. STATUS: MINUTEMAN II flight-test program (36 shots planned) began Sept. 24, 1964; 800 MINUTEMAN I's now operational; 1,000 missiles through FY '65; advanced version can be fired by airborne command posts; deployed in hardened and dispersed silos; MINUTEMAN II expected operational early in 1966; all MINUTEMAN I missiles to be replaced by MINUTEMAN II in phased replacement program costing $1 billion and beginning in 1966; same of the II's replace earlier models; MMII has greater accuracy (nearly 8 times more) and range/payload than I version; 14 successful MINUTEMAN II launches now completed, with most recent launch Dec. 14, 1965; maneuverable re-entry vehicle under development; several modifications beyond MMII already made.

NIKE-HERCULES (MIM-14B) (Army)

Western Electric, prime; Western Electric, guidance; Hercules and Thiokol, propulsion; Douglas, airframe. DESCRIPTION: Surface-to-air, anti-aircraft, tactical; weight, 10,000 lbs.; solid propulsion; warhead, nuclear or H.E.; range, 75 mi.; guidance, command; Mach 3+; ceiling in excess of 150,000 ft. STATUS: Over 80 batteries deployed in U.S. being turned over to National Guard; over 10 N-H batteries deployed overseas; Japan plans additional procurement; being equipped with HIPAR, a high-power acquisition radar, and anti-tactical-ballistic-missile capabilities. Re-location of some HERCULES batteries under consideration by JCS.

NIKE-X/Zeus (XLIM-49A) (Army)

Western Electric, prime; Bell Telephone, guidance; Thiokol/Lockheed, propulsion; Douglas, airframe. DESCRIPTION: Anti-missile missile, 3-stage; weight, 22,800 lbs.; solid propulsion; warhead, nuclear; range, 200-mi.; guidance, command; length, 48 ft.; diameter, 36 in.; fin span, 10 ft. STATUS: Missile is now part of NIKE-X missile "mix"; development, except as part of X, has ended; no intercept "failure" in more than a year of tests; $10 million requested for preliminary production engineering in FY 1966; advanced version of ZEUS (DM15X2) now under development reflects important breakthrough in long-range (400-mi.) ICBM interception.

NIKE-X (Army)

Western Electric, prime; Bell Telephone, guidance; Thiokol, ZEUS propulsion; Douglas, ZEUS airframe; Martin Marietta, SPRINT missile prime; Hercules and Lockheed, SPRINT propulsion. DESCRIPTION: Successor to ZEUS as an anti-ICBM system; uses a mix of ZEUS/SPRINT missiles and multi-function array radar (MAR). STATUS: Engineering development; funded at $400 million in FY '66 on accelerated development schedule, but deployment still deferred; GE will submit proposals on a hardened NIKE-X system. Tests to be conducted late this year with MAR at WSMR, N.M., could provide basis for deployment decision; deployment cost: $8-20 billion; key decision expected late this year.

PERSHING (MGM-31A) (Army)

Martin, prime; Bendix, guidance; Sperry Farragut, fuzing and aiming; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; two-stage solid propulsion; warhead, nuclear; range, approx. 400 n.mi.; guidance, inertial; transported on FMC M474 tracked vehicles; replaced REDSTONE. STATUS: Flight test program completed; troop firings from Ft. Wingate, N.M., to White Sands being conducted; number of missile-loaded launchers per unit to be increased; West Germany organizing two battalions; first U.S. PERSHING battalion deployed to Germany in April, 1964.

PHOENIX (AIM-54) (Navy)

Hughes Aircraft Co., prime; Rocketdyne, propulsion. DESCRIPTION: Air-to-air missile for use with the F-111B fighter aircraft; each aircraft will be able to carry six missiles. Missile control system designated AN/AWG-9; and missile/bomb launcher is MAU-48A. STATUS: Development; first flight test planned in March, 1966; $71 million in FY '66 funds.

POLARIS (UGM-27 A, B, C) (Navy)

Lockheed, prime; GE/MIT/Hughes/Honeywell/Raytheon, guidance and fire control; Aerojet-General/Hercules, propulsion; Lockheed, re-entry vehicle; Nortronics, checkout; Autonetics/Sperry, SINS; Westinghouse, launching equipment; Vitro, systems engineering coordination and training; Systron-Donner, ignition programming. DESCRIPTION: Underwater- and surface-to-surface; weight, 30,000 lbs.; solid propulsion; warhead, nuclear; range, 1,200 n.mi. (A-1), 1,500 n.mi. (A-2), 2,500 n.mi. (A-3); guidance, all-inertial. STATUS: 24 subs operational each with 16 A-2 or A-3 missiles; all A-1's now retired; A-3, operational in August, 1964; going on subs 19-41; total of 41 POLARIS subs authorized; deployed in Atlantic and Mediterranean; Pacific deployment began in 1964; British to buy A-3 missiles from U.S. POSEIDON, follow-on FBM, about to go into full-scale development; same contractors as POLARIS except for propulsion; Hercules/Thiokol first stage; Hercules second stage; same range as A-3 with double payload and accuracy; 50-month development effort; may go aboard 19 subs; PenAids and warhead can be field-changed.

QUAIL (ADM-20C) (Air Force)

McDonnell, prime; McDonnell, electronics, guidance; GE, propulsion; TRW, Inc., ECM equipment. DESCRIPTION: ECM-carrying decoy, which simulates B-52 bomber, to enemy radar; turbojet powered; range, 250 mi.; guidance, gyroscopic autopilot. STATUS: Deployed at SAC bases; carried by B-52; procurement completed FY '61; advanced version with 400-mi. range has been flight tested.

REDEYE (XFIM-43B) (Army)

GD/Pomona, prime; Atlantic Research, propulsion; MPB, Inc., seeker optics. DESCRIPTION: Surface-to-air; weight, 28 lbs.; solid propulsion; warhead conventional; guidance, IR-homing; length 48 in.; diameter, 2.75 in. STATUS: Production; tests against helicopters and jets at NOTS successful.

REGULUS I (RGM-6) (Navy)

LTV Aerospace Corp., prime; Sperry, guidance; Allison, propulsion. DESCRIPTION: Surface-to-surface; weight, 14,000 lbs.; turbojet and solid propulsion; warhead, nuclear; range, 500 n.mi.; guidance, inertial; speed, about 600 mph; ceiling, approx. 40,000 ft. STATUS: Five REGULUS subs with 17 missiles are operational now; 3 subs (8 missiles) phased out in FY '65.

SAM-D (Formerly AADS-70) (Army)

Hughes/Douglas/FMC, RCA/Beech, competitive component development contracts. DESCRIPTION: Field army aircraft/missile defense system, mobile. STATUS: DOD approved Army go-ahead for CDP; RFP's for CDP expected early January; Engineering development expected in FY '67; missile will replace both HAWK and NIKE-HERCULES; production could cost more than $2 billion.

SERGEANT (MGM-29A) (Army)

Sperry Utah, prime; Sperry, guidance; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; solid propulsion; warhead, nuclear; range, over 75 n.mi.; guidance, inertial; uses drag brakes. STATUS: Operational procurement complete; deployed in Europe; replacement for CORPORAL; West Germany buying system. $1.9 million requested in FY 1966 for warhead adaptation kits.

SHILLELAGH (MGM-51A) (Army)

Philco Aeronutronic, prime, Picatinny Arsenal/Amoco Chemicals Corp., propulsion; Aeronutronic, guidance. DESCRIPTION: Surface-to-surface; lightweight; solid propulsion; warhead, nuclear or H.E.; guidance, command; vehicle-mounted for use against field fortifications, armor and for close-in support of troops. STATUS: Production; initial procurement in FY '65; second-source procurement may come in FY '66; to use multi-system test equipment; to be installed on Gen. Sheridan assault vehicle; also being considered for use on helicopters; Philco has contract to adapt missile to Army's M-60 tank.

SHRIKE (AGM-45A) (Navy)

Naval Ordnance Test Station-China Lake, prime; Texas Instruments, guidance and control; North American Rocketdyne (McGregor), propulsion. DESCRIPTION: Air-to-surface, anti-radar; solid propulsion; guidance, passive radar homing. STATUS: Operational with Navy and Air Force; some reliability problems; advanced version under development.

SIDEWINDER I-C (AIM-9C&D) (Navy, Air Force)
Naval Ordnance Test Station, technical direction; Philco, IR guidance, Motorola, radar guidance; Naval Ammunition Depot, McAllister, motor loading; Rocketdyne (McGregor), propellant. DESCRIPTION: Air-to-air; weight, about 185 lbs.; solid propulsion; warhead, H.E.; range, more than 2 mi. STATUS: 1-A deployed with Navy and Air Force; 1-C version being procured as replacement for 1-A; NATO-built version now in production. (See CHAPARRAL).

SPARROW III-6B (AIM-7E) (Navy)
Raytheon, prime; Raytheon, airframe, control, guidance; Aerojet-General/North American Rocketdyne (McGregor), propulsion; McDonnell/Benrus Watch Co., launcher. DESCRIPTION: Air-to-air; weight, 350 lbs.; solid propulsion; warhead, conventional; range, 5-8 mi.; guidance, semi-active CW homing; Mach 2.5-3; ceiling, over 50,000 ft. STATUS: Earlier models operational with carrier aircraft; SPARROW III-6B prime armament for Phantom II (F-4B) and other high-performance interceptors; Italians buying NATO version for use of new F-104S; sales to West Germans and other NATO F-104 consortium members possible; Navy considering for air defense.

SPRINT (Army)
Martin-Orlando, prime; Hercules Powder/Lockheed Propulsion Co., propulsion; Bell Telephone Laboratories, guidance. DESCRIPTION: High-acceleration cone-shaped maneuverable missile for low-altitude interception of ballistic missiles; 4.5-ft. base diameter, 27 ft. long; two-stage; nuclear; missile will be popped out of silo before motor is ignited; to be part of the missile mix in a NIKE-X battery. STATUS: Development; first flight in March, 1965, tested vehicle aerodynamically; successfully tested from silo Nov. 17 at WSMR; extensive guidance tests underway; tests to move to Kwajalein in 12-18 months for use with NIKE-ZEUS and full radar system.

SRAM (Air Force)
Boeing and Martin Marietta won CDP awards of $2.75 million each. DESCRIPTION: Air-to-surface defense-suppression stand-off missile for use with the B-52, B-58, F-111 or the Advanced Manned Strategic Aircraft. STATUS: AF contracting feasibility tests for LASRM (Low-Altitude Supersonic Research Missile), aiming at doubling SRAM's range; Congress cut FY '66 budget request by $30.7 million; development decision not expected until August, 1966.

STANDARDIZED MISSILE (Navy)
No contractors. DESCRIPTION: Fleet air-defense missile to replace TARTAR-TERRIER and give Navy a single missile to perform both missions; longer-range targets (30+ miles) would be engaged by adding a booster to the shorter-range (10+ miles) weapon; similar to the homing TERRIER now being procured. STATUS: Development; expected to be procured initially in 1967-68; intended to work with new TARTAR-D digital fire control.

SUBROC (UUM-44A) (Navy)
Naval Ordnance Laboratory, technical direction; Goodyear, prime; General Precision Aerospace, guidance; Thiokol, propulsion; General Precision Librascope, fire control. DESCRIPTION: Underwater-air-underwater anti-submarine missile depth bomb; solid propulsion; warhead, nuclear; weight, 4,000 lbs.; length, 21 ft.; diameter, 21 in.; range, 25-30 mi.; guidance, inertial. STATUS: Production scheduled for installation in Thresher-class subs; operational evaluation under way.

SS-10 (MGM-21A) (Army)
Nord Aviation, prime. DESCRIPTION: Surface-to-surface, primarily anti-tank; weight, 33 lbs.; solid propulsion; warhead, conventional; range, 1,600 yards; wire-guided. STATUS: Operational with U.S., French and other NATO and Western units; battle-tested in North Africa; U.S. replacing with ENTAC.

SS-11 (AGM-22B) (Army)
Nord Aviation, prime. DESCRIPTION: Surface-to-surface anti-tank, also helicopter-to-surface; weight, 63 lbs.; solid propulsion; wire-guided; warhead, conventional; range, 3,800 yds. STATUS: Operational, used with airborne units and Army helicopters; AS-12 being considered by Navy for ASW aircraft.

TACTICAL PROBE (Navy)
Bendix, prime: DESCRIPTION: Surface-to-air; multiple, interchangeable payloads for each mission; booster, TERRIER or TALOS from shipboard installations; high-impulse second stage; range, 50-300 mi.; parachute descent. STATUS: Program definition; a new study has been authorized, and is under way, to evolve a cheaper program.

TALOS (RIM-8E) (Navy)
Bendix, prime; Vitro, systems engineering; McDonnell/Hercules Allegany Ballistics Lab., propulsion; Sperry, guidance; GE, launching gear. DESCRIPTION: Ship-to-air; weight, 7,000 lbs.; solid and ramjet propulsion; warhead, nuclear; range, 65 n.mi.; guidance, radar beam riding/semi-active homing; Mach 2.5. STATUS: Operational aboard cruisers Galveston, Little Rock & Oklahoma City and three Albany-class DEG's; Long Beach, nuclear-powered cruiser, has advanced TALOS; "3-T" get-well program increasing reliability; procurement continuing.

TARTAR (RIM-24B) (Navy)
Vitro, systems coordination engineering; Applied Physics Lab, design and development; GD/Pomona, Aerojet-General, propulsion; Sperry Farragut, fuze (target detection device). DESCRIPTION: Ship-to-air; weight, 1,500 lbs.; solid dual-thrust motor; warhead, conventional; range, 10 n.mi.; guidance, semi-active homing; Mach 2. STATUS: Operational; installed aboard 23 guided missile destroyers and three cruisers equipped with TALOS; get-well program progressing satisfactorily; CVA Kennedy will also have TARTAR.

TERRIER (RIM-2E) (Navy)
Vitro, systems engineering; GD/Pomona, prime; GD/Pomona, guidance section; Sperry, radar; Hercules Allegany Ballistics Laboratory, propulsion; Northern Ordnance, launching gear. DESCRIPTION: Ship-to-air; weight, 3,000 lbs.; 27 ft. long; solid propulsion; warhead, conventional; range 10 n.mi.; guidance, radar beam-riding or homing; Mach 2.5. STATUS: Operational aboard two attack carriers, 6 cruisers, and 12 missile frigates; get-well program progressing satisfactorily; being used in test firings against surplus REDSTONE missiles.

TITAN II (LGM-25C) (Air Force)
Martin, prime; TRW Systems Group, systems engineering and technical direction; AC Spark Plug, guidance; Aerojet-General, propulsion; GE, re-entry vehicle. DESCRIPTION: ICBM; weight, 330,000 lbs.; N_2O_4 and Aerozine-50 storable fuels; warhead, nuclear; range, over 5,000 mi.; guidance, inertial; 115 ft. long; 2 stages; greatest payload and range of any U.S. ICBM, basic core vehicle for TITAN III booster. STATUS: All 54 missiles operational in 18-missile squadrons at Davis-Monthan AFB, McConnell AFB, and Little Rock AFB.

TMRBM (Air Force)
No contractors announced, but probably would be same team producing the second and third stages of MINUTEMAN II. DESCRIPTION: A transportable mid-range missile to fill the gap left by cancellation of MMRBM; it would use the top two stages of MM II and the MM II guidance system; would weigh more and be less mobile than MMRBM, but could be developed for approximately one-third the cost; reaction time also less than MMRBM's; employment concept much the same as that of the Russian-deployed missiles in Cuba in 1962. STATUS: Study by the Air Force at DDR&E direction; not likely to be developed due to a lack of mission.

TOW (XMGM-71A) (Army)
Hughes, prime. DESCRIPTION: Anti-tank; weight, 160 lbs.; solid propulsion; warhead, H.E.; wire-guided; optically tracked; tube-launched. STATUS: Development; follow-on to ENTAC; successful firings have been conducted; helicopter use planned.

WALLEYE (Navy)
NOTS development; TV-guided glide bomb with good stand-off range; Martin reported winner of production competition; large buy expected; smaller version, called SNIPE, under NOTS development for Army helicopters.

ZUNI (Navy)
Naval Ordnance Test Station, prime; Hunter-Douglas, propulsion. DESCRIPTION: air-to-surface; weight, 107 lbs.; solid propulsion; warhead, conventional; range, 5 n.mi.; unguided; STATUS: Operational; designed for use on jet fighter and attack aircraft; big increase in orders because of Vietnam war.

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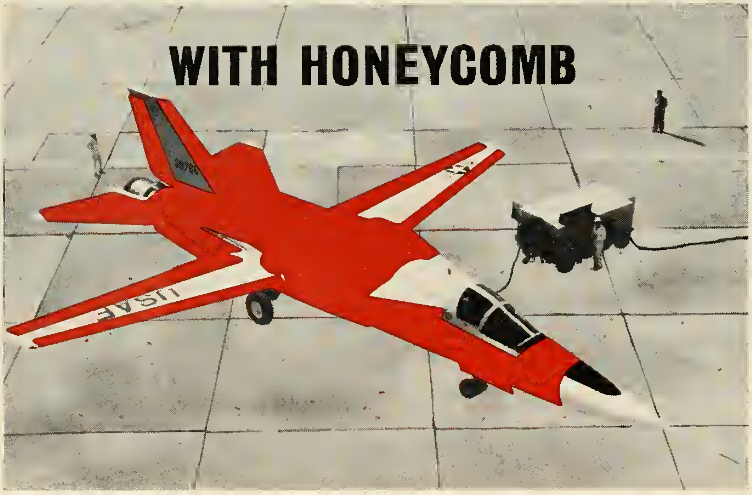
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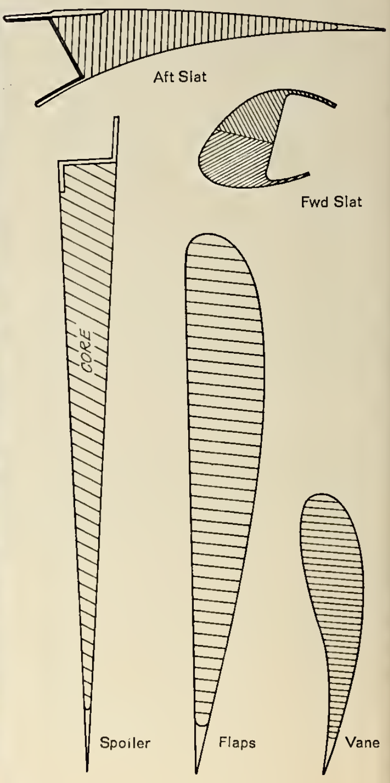
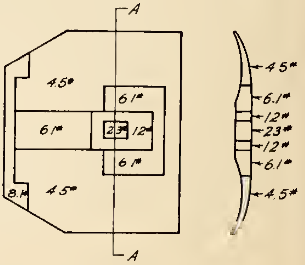
Typical Honeycomb Sandwich Contours

CORE IN WING


Aft Slat
Fwd Slat
CORE
Spoiler
Flaps
Vane

DISSIPATION OF CONCENTRATED LOAD—
Varying Core Density Saves Weight
8.1# = 8.1# Per Cu. Ft. Density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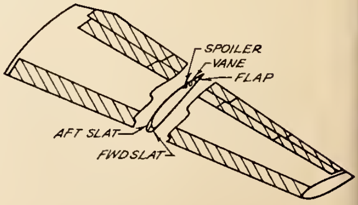
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VANE
FLAP
AFT SLAT
FWD SLAT

Technical Countdown

PROPULSION

Hercules Aiming for Tactical Missiles

A series of composite propellants are in development at Hercules Powder for applications in tactical air-launched and ground missile systems. Test motors have recently been fired at Allegany Ballistics Laboratory to demonstrate ability of the formulations to meet tactical missile specifications. Hercules has been deeply involved in strategic system propulsion such as *Polaris, Poseidon, Minuteman* and the *Sprint* and HIBEX programs, but this is the firm's first definite move into the highly competitive tactical propulsion field.

Hydrazine Rocket Under Contract

Rocket Research Corp. will design, build and demonstrate a 5-lb.-thrust flightweight rocket motor using the firm's hydrazine-Shell catalyst system. The engine is being funded under a $95,278 contract from NASA, with Jet Propulsion Laboratory handling the technical management. The motor will be designed for fast starts and shutdowns with a throttleable range of 10 to 1. Mixtures of hydrazine, nitric acid and water will also be used to drop the propellant freezing point to —20°F.

Cheap Fuze Available

A programmable long-delay fuze designed to withstand being dropped from aircraft is looking for a market. The unit is lightweight and reliable and will delay its function up to 24 hours after the drop. Designers at Rocket Power, Inc., Mesa, Ariz., say the unit can be made at extremely low cost and was originally conceived as an igniter for Primacord.

ELECTRONICS

Crowded Electrons Explode

Squeeze a lot of electrons into a small volume and they'll explode, carrying with them some of the material that made up the volume. This is the theory of Air Force scientists at the Office of Aerospace Research (OAR), who believe that the phenomenon, described as "electron overpressure," will affect studies of controlled thermonuclear power. The explosion, although predicted, was not observed until Heinz Fischer of OAR's Air Force Cambridge Research Laboratories devised the Narolite, a light source producing extremely brilliant pulsed light with nanosecond durations. Photographs of the afterglow after a spark discharge showed that about 30 nanosecs. after the current had ceased, a jet of material exploded from a small, discrete point on the anode surface. Lasting about 120 nanosecs., the jet resembles a water fountain, or the mushroom cloud of a microscopic explosion.

SPACE MEDICINE

Soviets Get Oxygen from Superoxide

Soviet life support systems as used in *Vostok* and *Voskhod* appear to use an alkali metal superoxide as a source of oxygen, says Dr. A. W. Petrocelli, of General Dynamics/Electric Boat Division. Specifically, he says, it appears through careful analysis of their available published works that the compound they have chosen is sodium superoxide. Petrocelli estimates that the Russians have outpublished the U.S. scientists about 3:1 in regard to basic research on these materials, and are continuing their effort to improve on what they have by studying possible life-support-system compounds such as new superoxides, peroxides and ozonides. In addition, he says, they are improving the operation of superoxides and searching for new and better carbon dioxide absorbers.

Helium No Threat to Intelligibility

No new communication intelligibility problems were created in a reduced-pressure environment when helium was added to the same oxygen partial pressure, the Air Force School of Aerospace Medicine has reported. A total of 13 simulated flights, involving 25 subjects and four chamber operators, was conducted. Some 8,300 numbers and words and 2,200 words in sentences were used to evaluate communication intelligibility in oxygen at 5 and 3.5 psia and in oxygen/nitrogen and oxygen/helium at 7 psia. Researchers found that speech intelligibility problems were no greater in the 50-50 oxygen/helium atmosphere at 7 psi than pure oxygen at 3.5 psi or 5 psi and, in some cases, were actually less.

Voskhod Radiation Dosage Uneven

Soviet *Voskhod II* pilot Pavel Belyayev got a slightly larger dose of radiation (75 millirads) than did his copilot and space walker Alexei Leonov, who received about 65 millirads during the 26-hour flight, according to Prof. Victor Bazykin, member of the USSR Academy of Sciences. Bazykin says the walls of the ship did not absorb the radiation evenly, and Belyayev was in a more exposed area.

Aerojet, USC Team on Manikin

Aerojet-General Corp. is teaming with the University of Southern California School of Medicine to create a computer-controlled manikin of lifelike proportions to aid in training of anesthesiologists. To be designed under a $280,000 grant from the Dept. of Health, Education and Welfare, the simulator will be sensitive to varying dosages of 10 different drugs —with simulated respiration, heartbeat and pulse, eye symptoms, color change and other human responses. Aerojet is instrumenting the simulator and will program its operation into a hybrid analog-and-digital computer, according to USC design.

SPACE STRUCTURES

Space Inflatables To Be Developed

Two new space vehicles capable of being shot into orbit and then inflated will be built and tested in model form by Goodyear Aerospace Corp. One is a cylindrical shelter for astronauts; the other is an umbrella-shaped solar collector. The two-part program is being conducted for Archer Daniels Midland Co. under a contract from the Research and Technology Div. of Air Force Systems Command, Wright-Patterson AFB, Ohio. The half-scale collector will be of a sandwich composition involving Goodyear's "Airmat" material. Successful completion of this phase will lead to a full-scale 52-ft.-dia. collector.

Test Engineering Openings at Boeing Atlantic Test Center

The Boeing Company's deep involvement in the nation's most important missile and space programs is providing qualified engineers and scientists career opportunities of unusual scope and growth potential. Boeing currently is weapon system integrator for the U.S. Air Force advanced Minuteman II ICBM, prime contractor for the National Aeronautics and Space Administration Lunar Orbiter moon-scanning satellite, and a major contractor on the NASA Saturn V launch vehicle.

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Vandenberg Begins Expanding for MOL

Acquisition of huge ranch adjoining space base will be first step toward meeting needs of continuous launching; new Titans planned

by Robert Lindsey

VANDENBERG AIR FORCE BASE, CALIF.—The U.S. Army Corps of Engineers has been negotiating to acquire the 14,891-acre Sudden Ranch properties adjacent to this base as the first step in a massive expansion program triggered by the *Manned Orbiting Laboratory (MOL)* program.

Brig. Gen. Joseph S. Bleymaier, commander of the Western Test Range, told MISSILES AND ROCKETS he sees "a real good possibility" that within five years Vandenberg will have "continuous manned operations," involving perhaps as many as 40 or more launches a year.

Meanwhile, M/R learned that last summer's *Titan III-X* studies have matured into firm designs for two new Air Force launch vehicles that will be used to orbit advanced unmanned reconnaissance satellites and other military payloads from Vandenberg. They include:

—*Titan III-B*. This will consist of the first two stages of the *Titan III-A*, less the malfunction detection system and other man-rating equipment, plus an upper stage. Initially at least, it will be used only with an *Agena* upper stage. The *Titan III-B* will be radio-guided and be capable of orbiting payloads of about 8,000 lbs.

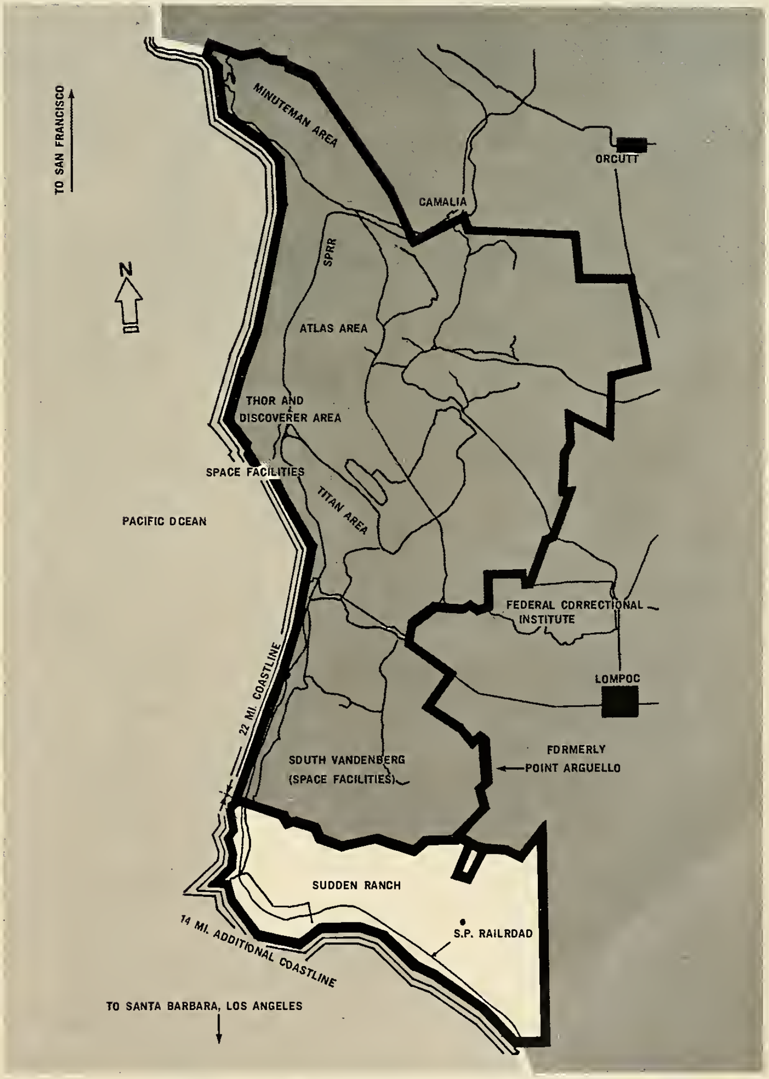
—*Titan III-D*. This will consist of the *Titan III-B, Agena* or other upper stage, plus two two-segment, 120-in.-dia. solid motor strap-ons. Payload will be about 50% greater than that of the *Titan III-B*, or approximately 12,000 lbs. A three-segment strap-on motor design is still under consideration.

In still another version of the *Titan III*, use of seven-segment 120-in. motors (instead of the five-segment motors used in *Titan III-C*) apparently has been firmed up for the *MOL* launches from Vandenberg. For a time at least, Air Force sources said, 156-in. motors have been ruled out of the *MOL* program.

United Technology Center of Sunnyvale, Calif., is now working on a Program Definition Phase (PDP) contract for the seven-segment motor. Informed sources say the firm will get a development contract early this year.

The seven-segment motor probably would produce about 1.5 million lbs. of thrust, compared with 1.2 million lbs. of the *Titan III-C* motor. Designation of the *Titan III* employing seven-segment motors hasn't been determined as yet, although one source said it would be dubbed *Titan III-E*.

Unmanned activity—While this Strategic Air Command base is being readied for what promises to be a fast-paced program of manned space oper-


TO SAN FRANCISCO
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TITAN AREA
PACIFIC OCEAN
FEDERAL CORRECTIONAL INSTITUTE
LOMPOC
22 MI. COASTLINE
SOUTH VANDENBERG (SPACE FACILITIES)
FORMERLY POINT ARGUELLO
SUDDEN RANCH
S.P. RAILROAD
14 MI. ADDITIONAL COASTLINE
TO SANTA BARBARA, LOS ANGELES

Map shows how purchase of 14,891-acre Sudden Ranch (light area) south of existing space facilities will add substantially to both ground area and coastline.

Rocketdyne

Career Openings In Solid Propulsion

Rocketdyne's Solid Rocket Division in Central Texas offers outstanding opportunities to advance professionally in solid propulsion research, engineering, and production. Current major programs include Phoenix, Sparrow, Shrike, and Sidewinder.

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Conduct analyses in structural mechanics, mechanical shock and vibration, and viscoelastic stress, as related to solid rocket motors. Strong background in mathematics and one or more of above listed applied mechanics fields is necessary.

Research Chemist

Conduct necessary chemical-physical property measurements and tests on rubber, plastics, and adhesives as related to the processing and evaluation of these materials for solid propellant rocket motor liners and insulation.

Test Engineering

Conduct required tests, interpret results, and establish new testing techniques using appropriate equipment in either sonic and ultrasonic or radiographic fields of specialization.

Internal Ballistics

Conduct design and specification of solid rocket motor ballistic characteristics and charge design, plus analysis and evaluation of performance, using principles of thermodynamics, fluid mechanics, and stress analysis.

Reliability

Conduct reliability analyses and studies relative to solid propellant motor designs, and serve as reliability representative to specific program task teams and related special project activity.

Design

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ations, the tempo is also rising in the unmanned military space activities.

Modification of a former *Atlas-Agena* launch complex to handle the *Titan III-B* is now well under way and is scheduled to be completed late this year (M/R, Dec. 20, p. 9).

Although payloads assigned to the *Titan III-B* are classified, it is believed that the primary one is a larger version of the *SAMOS* reconnaissance satellite. *SAMOS* is now launched by an *Atlas-Agena* with a payload capability of about 7,000 lbs. Apart from its payload increase, *Titan III-B* would give this program the flexibility and quick response possible with storable propellants, not available with the *Atlas-Agena*. Larger payloads resulting from use of *III-B* and *III-D* would permit several reconnaissance refinements, including multiple film recovery capsules.

Early *MOL* qualification flights will be conducted from Cape Kennedy, but all manned *MOL* missions will be flown out of Vandenberg, to take advantage of the facility's capability to launch payloads into polar orbits.

$53 million in construction—Bleymaier estimates construction of the initial launch capability (ILC) complex for the *MOL* will take about 30 months. Hence, the launch complex should be ready for the first manned *MOL* flight in late 1968. Bleymaier said he expects work on the Sudden Ranch to hit full swing in about March. Estimated cost of ILC, an "all-purpose" facility that will also handle *Titan III-D*, is $28 million.

The single launch pad of the ILC will, in effect, be the core of the *Titan III* Integrate-Transfer-Launch (ITL) complex at Cape Kennedy. Ultimately, Bleymaier said, construction of an entire ITL here is inevitable. But he said the decision probably won't be made for "another couple of years." This points to the ITL becoming operational in about 1969 or 1970. Estimated cost of completing the ITL is about $25 million, in addition to the ILC costs, Bleymaier said.

Although there has been support for establishing the *MOL* mission control center at Vandenberg or at the Air Force Space Systems Division headquarters at El Segundo, Calif., sources said there have been no changes in early plans to give the mission to the Air Force Satellite Test Center at Sunnyvale (M/R, Nov. 22, p. 16).

"Time of Transition"—Bleymaier, the main driving force behind the highly successful *Titan III* program and a leader in early *MOL* planning, conceded that he's now seeing space operations from a new light.

"For years," he said with a grin, "I was able to lay down requirements on the ranges. Now I'm finding that having to satisfy the requirements laid down by others can be a real challenge."

This is a "time of transition" for the Western Test Range, he observed. Until now, he said, space operations here have been conducted from converted ballistic missile launch pads.

"Now for the first time we are building facilities for space from the ground up," giving the Air Force opportunities to optimize facilities to fit its needs more precisely.

Bleymaier said the WTR will require only "moderate" augmentation to handle manned flights, essentially addition of biomedical monitoring facilities along the range.

He noted that extensive space medicine facilities are being included in a new 125-bed base hospital now under construction—another sign that Vandenberg is going into the manned space flight business. ■

AF Orders New 'Long Tank Thors'

LONG TANK THOR, a new version of the Douglas *Thor* space booster offering greater payload capability, will be used for the first time this summer, the Air Force has announced.

Approximately 70 ft. long, compared with 56 ft. for previous models, the new vehicle is essentially a *Thrust-Augmented Thor (TAT)* with a longer tank and upgraded solid-propellant strap-ons. The three strap-ons are off-the-shelf Castor II solid motors which add a total of 18,000 lbs. of thrust more than the Castor I motors used on the *TAT*. Thrust of a single Castor II is 70,450 lbs., compared with 64,530 for Castor I.

Air Force Space Systems Division has ordered 22 of the new vehicles from Douglas Missile and Space Systems Div., Santa Monica, Calif., at an estimated cost of $18 million. These are all production models, not modified older versions, and the Air Force expects to utilize them quickly and order further production. In the usual process of standardization, it says, the new *Thor* eventually would replace all older versions for Air Force and NASA missions.

Thrust of the main engine remains at 170,000 lbs. Total thrust of the *Long Tank Thor* is 348,000 lbs. Increased payload capability is achieved with longer burn time.

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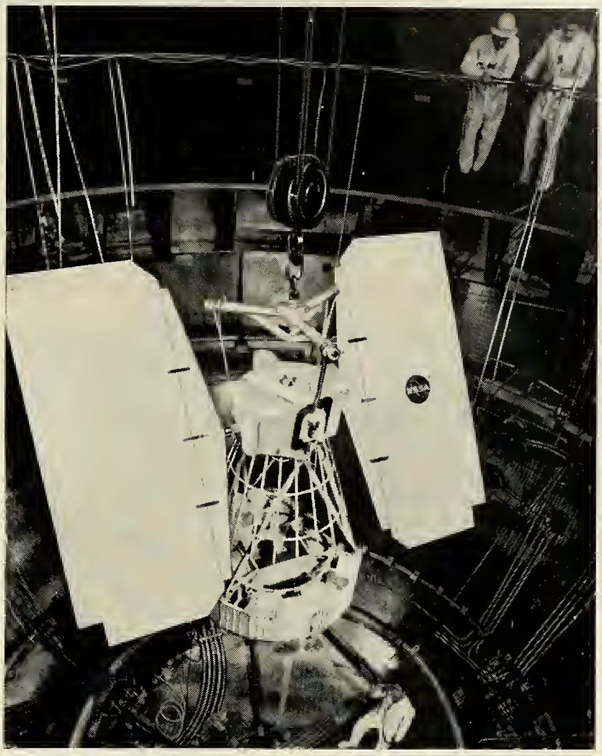

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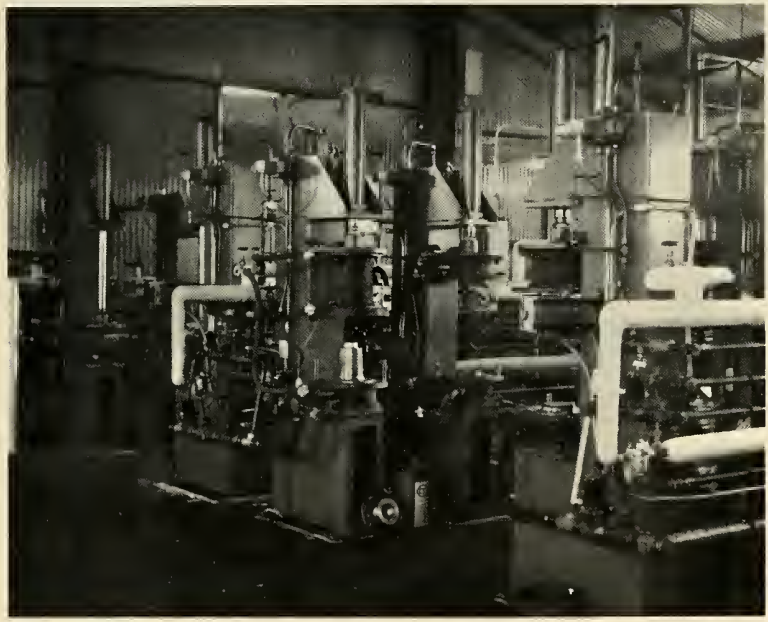
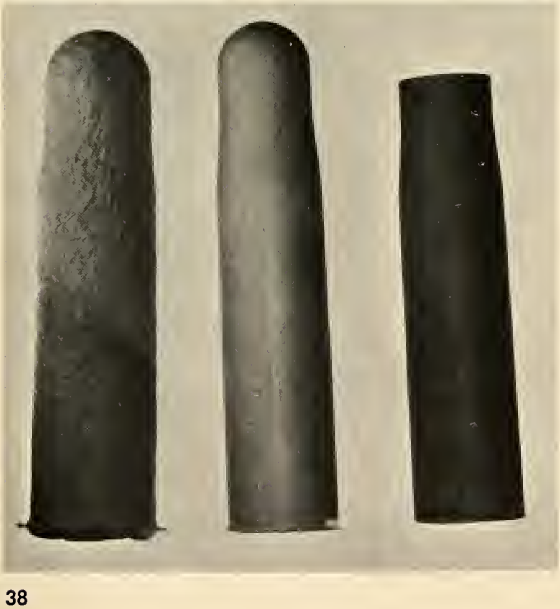
Shillelagh Round To Boast Fully Combustible Casing

by John F. Judge





Above: Semi-automated production lines for Shillelagh companion round cartridge case at Western Molded. Center section subassembly die is shown on center press line. Raw stock mixtures are fed into lines from large mixing tank. Left: Combustible artillery case shown in the three steps of manufacture. First, the preform section; second, molded cartridge case; third, impregnated and trimmed case. This is not the Shillelagh companion round case.

Gardena, Calif.—The *Shillelagh* companion round for the Sheridan assault vehicle will use a fully combustible cartridge case—the first such produced for U.S. military use.

The case burns completely on firing, leaving no residue and eliminating the extraction of spent cases. The *Shillelagh* case is being manufactured by Western Molded Fibre Products, Inc., a subsidiary of the Hawley Products Co.

The manufacturing process was developed by the firm and is proprietary. The contract was awarded by the Picatinny Arsenal, U.S. Army Munitions Command, Dover, N.J. Picatinny has been instrumental in the development of both consumable and combustible cartridge cases.

The case consists of a mixture of both "live" fibers such as nitrocellulose, and inert wood cellulose fibers. P. L. DeLuca, president of Western Molded Fibre, says that nitrocellulose is a potentially hazardous material but careful process controls and an inherent respect for its properties reduce this problem to a minimum.

Vacuum die operation—The cases are fabricated by first immersing perforated dies in an aqueous slurry containing a proper fiber mixture. Pulling a slight vacuum on the die for a controlled period results in the formation of an accrete—an oriented felt covering the shaped die.

The moist felt is transferred to a heated die, which squeezes much of the water out with the aid of both low heat and a vacuum. The felted part is still moist and contains enough water to render the nitrocellulose fibers inert.

The next step in the operation impregnates the part with a specific resin in an open die arrangement using a water-soluble solvent. A curing operation tacks the resin and removes the remaining water. The part is then shaped by pressing to the final dimensions.

The process is semi-automated at Western Molded Fibre. The *Shillelagh* companion case is produced as two subassemblies that are subsequently joined in the arming and loading operation. The latter is not performed by Western.

The firm does a thriving business in molded components for the military and DeLuca feels there are other potential markets for both combustible and consumable cartridge cases—either fully fibered or fiber sidewalls with metal obturating bases.

There is also a potential market in supplying molded fiber dummy warheads for practice applications in the 2.75 rocket, 5-in. auxiliary rocket and 90 to 105 mm artillery rounds. About $20 million worth of such rounds are used each year by all services and the

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RANGE SAFETY Study and develop areas of explosive hazard assessment, including instrumentation to cover chemical fuel explosions and nuclear fuel excursions.

INSTRUMENTATION & VEHICLE CONTROL Add a 64-man central control at the Cape to direct operation of the entire range...new real-time dual-system computer facility (including 2 CDC 3600's) for failure-proof high-speed data handling.

CORRELATION Reduce time correlation uncertainty across the range to less than 10 microseconds...standardize the timing signal format on the Eastern Test Range to be compatible with other national ranges.

FREQUENCY CONTROL & ANALYSIS Monitor and control all electromagnetic radiation within the missile test area with a Spectrum Surveillance System...expand automatic interference control, spectrum signature collection, and quality analysis.

METEOROLOGY Improve cloud height and growth indication instrumentation...develop a system to measure atmospheric electrical potential and cloud movement.

SHIP & AIRCRAFT INSTRUMENTATION Improve the instrumentation to meet more stringent telemetry, navigation, tracking, communications, and data handling requirements...phase into operation new and/or modified tracking ships and aircraft.

UNDERWATER SOUND Refine the techniques employed to establish impact location points of nosecones and instrumentation cassets.

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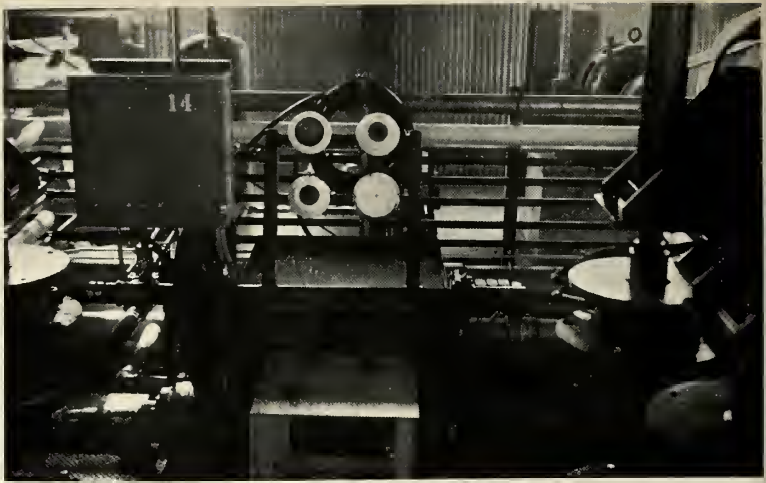


Initial accreted felts emerging from fiber blend tank are shown still on vacuum forming dies. Die complex flips back into and out of blend tank behind die holder. Parts are then transferred to heated dies, to remove major portion of moisture and compress fiber felt.

savings in shifting to molded fiber warheads could be significant.

Fiber cheaper—DeLuca analyzed the economics in producing 90, 105 and 120 mm rounds by both the metal and fiber approaches. The fiber route in this case involved consumable sidewalls and metal obturating bases. An average cost reduction of 60% was apparent.

In the analysis, DeLuca cited the cost of a metal 105-mm brass cartridge case to the Army as $13.50 with a weight of about 13.5 lbs. The same case, using consumable sidewalls and a metal obturation base assembly should cost about $4.25 and weigh only 3.7 lbs.

The average cost to the Navy for steel 5-in. 38 cartridge cases is $8.70 each with a weight of 12.7 lbs. The consumable sidewall-metal base route would reduce the weight to 4.7 lbs. and the cost to $5.50.

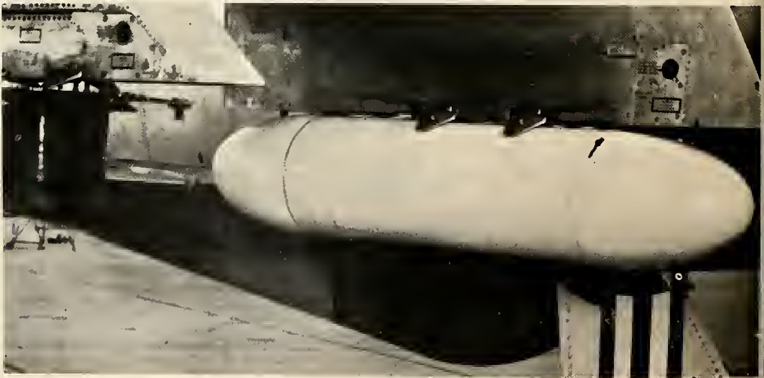
Tests at Western Molded Fiber indicate the consumable and combustible cases can meet the same handling, compression-loading ramming, storage and environmental conditions as the all-metal case. In addition, the non-metal materials involved are not considered strategic—as is brass.

The only difference between a consumable and a combustible case is that the latter has live fibers—both are consumed in the firing.

The process used in the manufacture of the *Shillelagh* companion round case is similar to that employed by Western in the fabrication of frangible nose and tail cones for airborne rocket and other stores systems.

The frangible sections are strong enough to take the aerodynamic loadings imposed by the fastest military aircraft. DeLuca has patented the basic fairing design (U.S. 3,140,638).

Weapons storage pod in flight condition. Forward and aft sections are frangible in the case of rocket-loaded pods. The 2.75 pod is open at the aft section, but has a frangible skirt for aerodynamic purposes.



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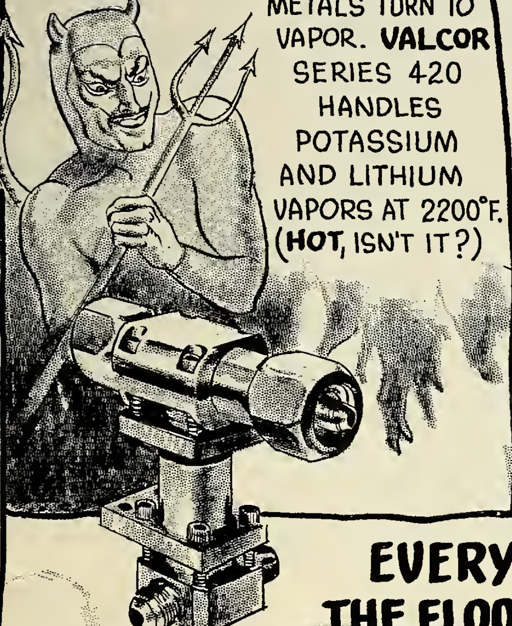

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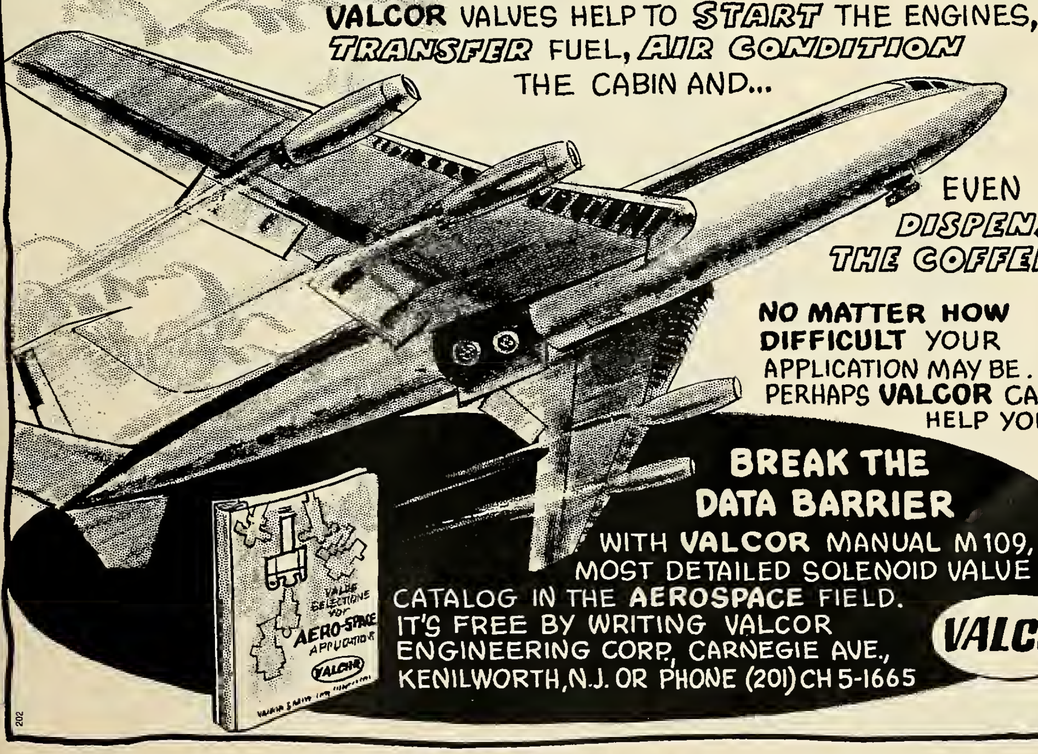
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Fragmentation details—When the rockets are fired from within the launcher housing, the frangible fairings are broken. DeLuca's grenade-type construction eliminates the danger of having fragments impacting and causing damage to the fuselages, wings and tails of jet aircraft.

The fragmentation pattern is achieved by molding a thin-walled fiber shell with integral networks of structural weaknesses. The thinner areas of the shell have a higher fiber density than the thicker webbing.

The distribution of fibers in the shell creates a predisposition to break at the points of relatively low density. In addition, the low-density areas gather excessive amounts of resin in the fabrication process. This sets up shear conditions because of the brittleness inherent in these resin levels.

The frangible units are used to house 2.75 rockets, machine guns and other aircraft stores. Western is currently developing a frangible nose pod for General Electric's Vulcan M-61 rapid-fire gun.

The firm is also looking at consumable and combustible cartridge cases for applications in addition to the *Shillelagh* weapons systems. ■

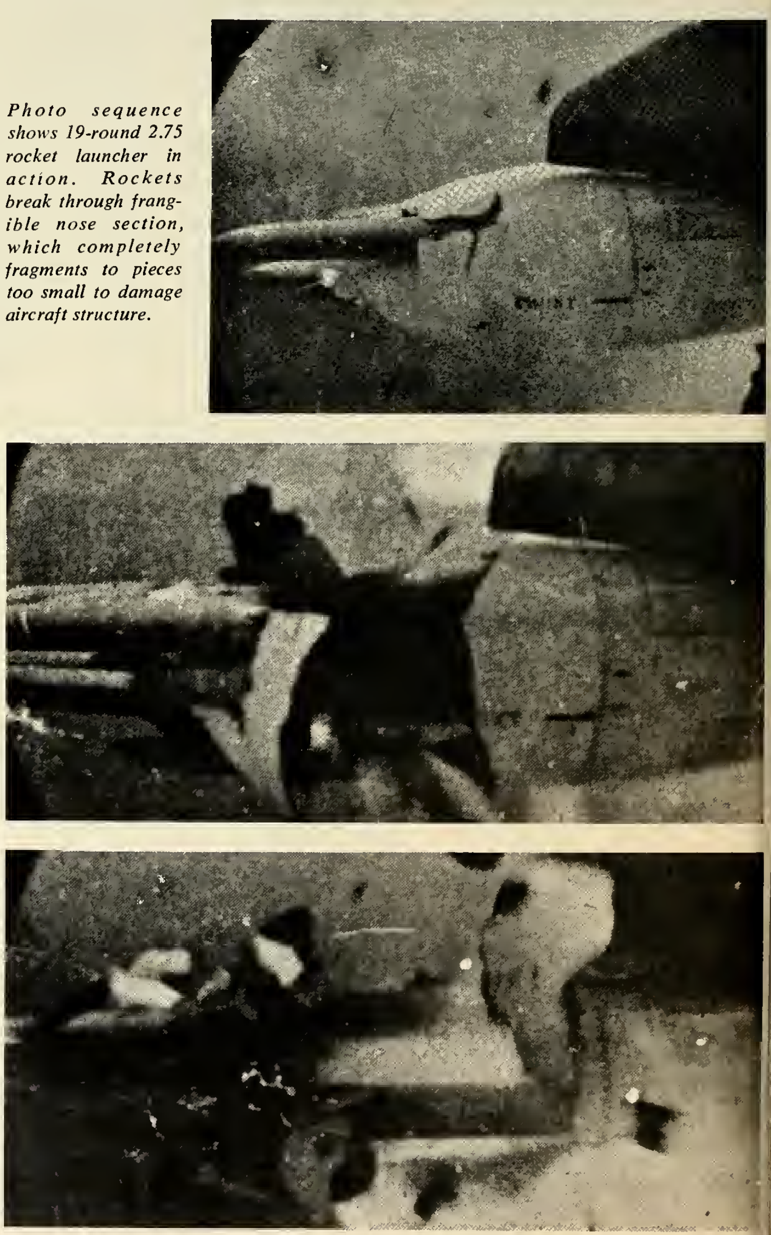

Photo sequence shows 19-round 2.75 rocket launcher in action. Rockets break through frangible nose section, which completely fragments to pieces too small to damage aircraft structure.

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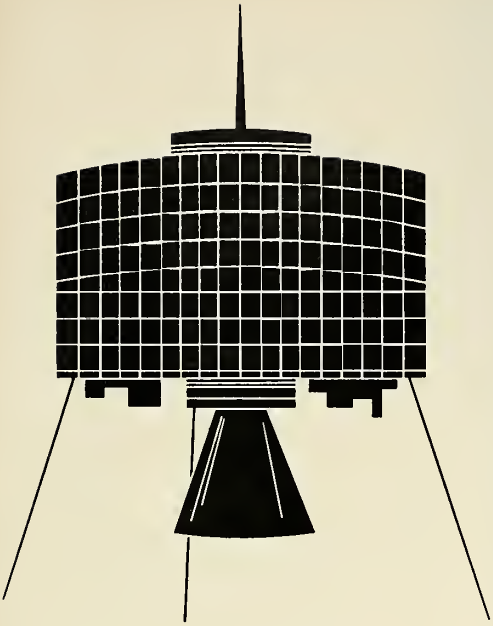

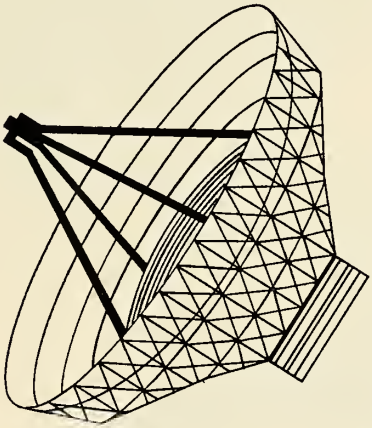

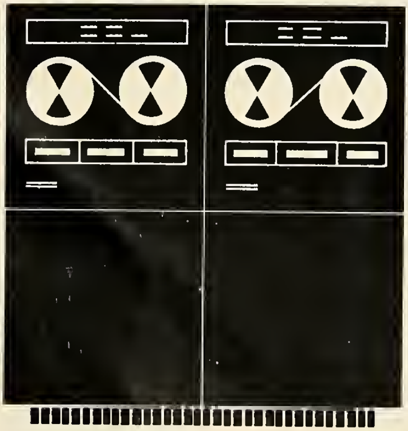

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The Industry Week

Mergers and Acquisitions

Automation Industries, Inc., El Segundo, Calif., is purchasing all outstanding stock of Forster-Hoover Electronics, Inc., Ann Arbor, Mich. The firm, which has been renamed Automation-Forster, manufactures non-destructive testing equipment. It will be operated as a wholly owned subsidiary of Automation. . . . *Spectran Electronics Corp., Pompano Beach, Fla., has been merged into Novatronics, Inc., also of Pompano Beach. The firm produces spectrum analyzers and accessory items and will be operated as the Spectran Electronics Div. of Novatronics. Novatronics was formed early last year to acquire and continue the business of the Hoover Co.'s Electronics Div., Pompano Beach.* . . . Computer Sciences Corp., El Segundo, Calif., has announced an out-of-court settlement of a suit to rescind its acquisition of Potter Aeronautical Corp., Union, N.J. Under the settlement, David M. Potter, president of Potter, will return more than $1.9 million in Computer Sciences stock, plus other reimbursements. According to CSC, Potter's financial position was not as it was represented to be at the time of acquisition last August. . . . *Lear Siegler, Inc., Santa Monica, Calif., is acquiring all assets of Cimron Corp., San Diego, Calif. The move includes acquisition of Norfax Corp., a Cimron subsidiary, and involves an undisclosed amount of LSI preferred and common stock. Cimron produces digital instruments and systems.* . . . Bendix Corp., Detroit, plans to purchase the assets of Beck-Lee Corp., Chicago producer of electronics equipment. . . . *Warner & Swasey Co., Cleveland, plans to purchase the Solon, Ohio, plant of Lewis Welding & Engineering Co. The 124,000-sq.-ft. plant is designed for metal-working manufacturing.* . . . Information Handling Services, Inc., Englewood, Colo., has acquired the CSMF Microfilm Catalog File from the Petroleum Publishing Co., Tulsa, Okla.

International

Design studies are underway for construction of a 400-ft.-dia. radio telescope to be used by the radio astronomy station of Manchester University, England. The telescope would be built at Jodrell Bank at an estimated cost of more than $6 million. Construction could take as long as five years. . . . *Petro-Tex Chemical Corp., Houston, has licensed a production process for neoprene synthetic rubber from Distillers Co., Ltd., Edinburgh, Scotland. The firm is building a new plant with a planned production capacity of 45 million lbs. Prior to beginning production, Petro-Tex will import neoprene from France under an agreement with Distugil, S.A.* . . . Honeywell, Inc., Minneapolis, has announced plans to make a $20 million offering of sinking-fund debentures in Europe. The offering will be made through a recently formed Luxembourg subsidiary, Honeywell International Finance Co.

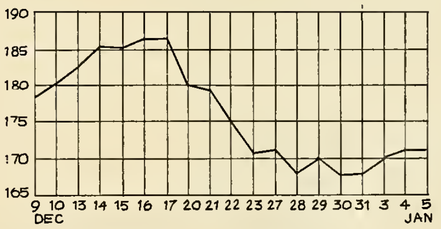
New Activities

Texas Instruments, Inc., Dallas, has established an oceanographic surveys branch within the Science Services Div. Dr. Richard A. Geyer will head the group. . . . *Space-General Corp., El Monte, Calif., has been named an industrial associate of the University of Southern California's School of Engineering. Under the agreement, Space-General will conduct seminars and cooperate in discussions at the school's new Research and Educational Center.* . . . RdF Corp., Hudson, N.H., is establishing a wholly owned subsidiary in California. The plant will design and manufacture solid-state electronic signal transducers. A suitable plant site is now being sought. . . . *Radiation Applications, Inc., Long Island City, N.Y., has changed its corporate name to RAI Research Corp.* . . . Electro-Ceramics, Inc., Salt Lake City, has been renamed Edo Western Corp., a result of its diversification policy into production of oceanographic and acoustic instrumentation systems. Electro-Ceramics will be retained as the name of a division of EWC and will specialize in production of technical ceramics and piezoelectric products. . . . *The Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn., has changed its name to Oak Ridge Associated Universities. The institute will continue as a unit of ORAU.*

Facility Expansions

Union Carbide Corp.'s Linde Div., Amarillo, Tex., has doubled its liquid helium production by modification of the liquefaction process. The firm's helium liquefaction capacity is now 260 liters per hour. . . . *MSA Research Corp., has dedicated a new research and manufacturing facility at Callery, Pa. The firm conducts research and engineering in such areas as life-support systems, liquid metals and liquid-metal hardware.* . . . Lockheed Missiles & Space Co. plans to begin construction of a marine terminal adjacent to its Marine Laboratory in San Diego, Calif. The terminal will include facilities for maintenance and support of the Deep Quest submarine and Sea Quest, an oceanographic research vessel.

Missile/Space Stock Index



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AIR FORCE

$2,535,000—**Emerson Electric Co.,** Electronics and Space Div., St. Louis, Mo., increment to previous contract for automatic test equipment for *Minuteman* missile systems and F-111 aircraft.

$2,000,000—**General Electric Co.,** Philadelphia, increment to previous contract for flight testing of the maneuvering ballistic re-entry vehicle.

$2,000,000—**Thiokol Chemical Corp.,** Huntsville, Ala., initial increment to $5-million estimated contract for production of solid rocket motors.

$1,655,299—**General Dynamics Corp.,** San Diego, Calif., for design and fabrication of re-entry vehicle instrumentation and range safety systems.

$322,885—**Ets-Hokin Corp.,** Wilmington, Calif., for containers for *Bullpup B* missiles and data.

$184,083—**Thiokol Chemical Corp.,** Elkton Div., Elkton, Md., for *Iroquois* rocket motors.

$89,298—**Avco-Everett Research Laboratories,** Everett, Mass., to study radiative properties of heated air.

$72,352—**California Institute of Technology,** Pasadena, Calif., for research in laser electromagnetics.

$64,743—**IIT Research Institute,** Chicago, for study of fundamentals of liquid propellant sensitivity.

$59,080—**Battelle Memorial Institute,** Columbus, Ohio, for research toward high energy propellants.

ARMY

$71,393,000—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for the "second buy" of *Shillelagh* guided missiles. Also, $3,310,501 to adapt the *Shillelagh* missile system to the U.S.-Federal Republic of Germany Main Battle Tank for the '70's (US/FRG MBT-70).

$4,663,188—**Raytheon Co.,** Lexington, Mass., for FY 1966 industrial engineering services for the *Hawk* missile system. Also, $1,653,097 for maintenance and modification of special tooling and test equipment to support the *Hawk* missile system.

$2,689,000—**General Time Corp.,** New York City, for military rocket fuzes.

$1,210,487—**Avco Corp.,** Ordnance Div., Richmond, Ind., part of $2,474,615 contract for rocket fuzes.

$419,092—**Aerojet-General Corp.,** Azusa, Calif., study of an infrared guidance system.

$150,000—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., one-year contract to measure the behavioral characteristics of ions at altitudes between 10 and 80 kilometers.

$99,773—**Thiokol Chemical Corp.,** Huntsville Div., Redstone Arsenal, Huntsville, Ala., for study in fast-burning rate rocket propellant research.

$59,484—**Lockheed Missiles and Space Co.,** Huntsville, Ala., for development of procedures for the analysis of a missile during an R&D test program.

$40,000—**Electro-Tec Corp.,** Ormond Beach, Fla., for wiring harness assemblies for use in the *Pershing* missile launcher.

NAVY

$64,965,121—**Aerojet-General Corp.,** Azusa, Calif., fixed-price incentive contract for production of the Mod 1 version of the Mk 46 torpedo.

$42,573,742—**Honeywell, Inc.,** Minneapolis, Minn., fixed-price incentive for production of the Mod 1 version of the Mk 46 torpedo.

$4,406,000—**Motorola, Inc.,** Military Electronics Div., Scottsdale, Ariz., for missile parts.

$710,427—**Sperry Rand Corp.,** Sperry Farragut Co., Bristol, Tenn., modification for FY 1966 buy of *Shrike* missile.

$475,000—**General Dynamics Corp.,** Pomona Div., Pomona, Calif., modification for R&D directed to existing and future configurations of *Terrier* and *Tartar* missiles.

$216,186—**Edwin A. Keehle Associates,** Nashville, Tenn., for preparation and updating of information in support of maintenance production and configuration control of surface missile systems.

$206,342—**Westinghouse Electric Corp.,** Sunnyvale, Calif., for *Poseidon* Phase 1-C standby engineering.

$59,000—**Sanders Associates,** Nashua, N.H., modification for *Shrike* missile antenna.

$53,250—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for laser subsystem.

NASA

$1,030,000—**Philco Corp.,** Western Development Laboratories, Palo Alto, Calif., from Ames Research Center for magnetometer experiment for *Pioneer C* and *D*.

$840,000—**Marshall Laboratories,** Torrance, Calif., from Ames Research Center for plasma probe experiment for *Pioneer C* and *D* spacecraft.

$305,000—**Curtiss-Wright Corp.,** Wright Aeronautical Div., Wood-Ridge, N.J., from Manned Spacecraft Center for development of a segmented, axially conducting, pyrolytic graphite reaction control engine.

$266,111—**Airborne Instruments,** Deer Park, N.Y., from Goddard Space Flight Center for cooled wideband parametric amplifier system.

$149,956—**IIT Research Institute,** Chicago, from Western Operations Office for study of protective coatings for refractory materials for liquid rocket engines.

$128,311—**Control Science Corp.,** Alexandria, Va., from Goddard Space Flight Center for triaxial electron analyzer.

$99,925—**Lockheed Aircraft Corp.,** Lockheed-California Co., Burbank, Calif., from Manned Spacecraft Center for development of a spacecraft landing strut.

$95,278—**Rocket Research Corp.,** Seattle, Wash., for demonstration of a five-pound-thrust flightweight hydrazine rocket engine.

$70,000—**University of California,** Berkeley, Calif., from Marshall Space Flight Center for research on the motions of artificial satellites.

$29,100—**Westinghouse Electric Corp.,** Aerospace Div., Baltimore, from Manned Spacecraft Center for integrated circuit helmet transceivers and set of extra functional circuit blocks for them.

INDUSTRY

$2,400,000—**Northrop Corp.,** Nortronics Div., Palos Verdes Estates, Calif., from **North American Aviation,** Autonetics Div., Anaheim, Calif., for follow-on production of auxiliary gyroscopes used in the *Minuteman II* inertial guidance system program.

$275,000—**Electronic Communications, Inc.,** Benson Manufacturing Div., St. Petersburg, Fla., from **United Aircraft Corp.,** Windsor Locks, Conn., for 21 canister and reservoir assemblies for *Apollo* backpack life support system.

$252,000—**ITT Corp.,** Cannon Electric Div., New York City, from **Lockheed Missiles and Space Co.,** Sunnyvale, Calif., for umbilical connector assemblies for the *Polaris* missile program.

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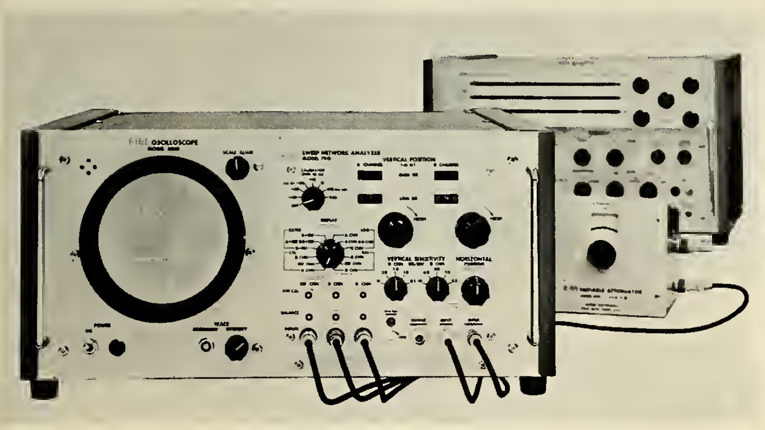

New Product of the Week: Power Level/Ratio Measurer

A swept power level and ratio measurement system with 60-db dynamic range has been developed by Alfred Electronics.

The Model 8000/7051 system measures gain, loss, absolute or relative power levels, VSWR and impedance magnitude (reflection coefficient).

The unit operates with crystal detectors using internal analog electronics to compensate for crystal performance above the square-law region. A built-in precision RF signal generator provides calibration for power level measurements. Accuracy is ±0.3 db at +20 dbm and ±0.6 db at −40 dbm. A ratiometer mode measures the db ratios of any two signal levels compared to a third with 2% accuracy for direct readout of reflection or transmission performance.

CRT sensitivity is adjustable from 0.5 db/cm to 10 db/cm. Offset adjustment of up to 60.0-db gain or loss direct reading to 0.1 db independently in each channel eliminates the need for external precision attenuators, the firm said.

Circle No. 151 on Subscriber Service Card

Welder Conversion System

Thermal Dynamics Corp. is marketing a conversion system, designed to adapt other arc welding equipment for the plasma welding process.

The Model W-100 system includes a plasma welding torch, a junction console and all console-to-torch leads and hoses. The customer uses his own dc power source, high-pressure cooling system, high-frequency arc starter and service leads.

Circle No. 152 on Subscriber Service Card

Slip-Ring Capsule

Electro-Tec Corp. is marketing a 12-circuit slip-ring capsule that operates over a temperature range of −55° to 125° C.

The P/N 17091 has a current-carrying capacity of 1 amp maximum and is high-pot tested at 500v for 10 secs. Circuit resistance including leads is 0.33 ohms maximum. Dynamic contact resistance is 10 milliohms maximum with 2 rpm superimposed 3°(±1°) double amplitude at a frequency of 2 cps. The unit has a torque of 0.25 in./oz. maximum and has been life-tested for 1,500 hours minimum. It meets MIL-E-5272C specifications.

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Null Detector

John Fluke Manufacturing Co., Inc., is marketing a solid-state null detector and microvoltmeter, available in line or rechargeable battery versions.

The instruments, Models 845A and 845AB, have an input impedance of 10 megohms on ranges of 1 microvolt to 1 millivolt and 100 megohms on ranges of 300 millivolts to 1,000v. Input isolation is 10^{12} ohms. The units have 19 end-scale ranges from 1 microvolt to 1,000v with ±2% accuracy.

They withstand up to 1,200v dc overload on any range. D-C common mode rejection is better than 180 db. A-C common mode rejection is 120 db.

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BIT ERROR RATE MONITOR

Compares serial data bits, DC to 2 MC

Accumulates, stores, and displays bit errors

Direct 3 or 4 digit display of bit error rate

Internal data delay compensation: 0 to 5 bits

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Bit matches selectable in place of bit errors

Wide application as general purpose comparator

The DEI Bit Error Rate Monitor provides a means of comparing two serial NRZ data bit streams on a bit by bit basis. It accumulates the number of negative or positive comparisons over a bit interval selectable 10^3 to 10^7 bits or on a continuous basis. Provision is made for processing code forms other than NRZ. The number of bit errors (or bit matches) are presented on a visual digital display while simultaneously presented in BCD form as a printer output.

The BA-102 Series can be used in conjunction with PCM serial simulators to measure bit error rate of PCM processing systems. Operation is provided at bit rates from DC to 2 megacycles with data 1/0 threshold adjustable from +7 to −7 volts.

The power supply is self-contained and input/output connections are provided on both the front and the rear of the unit. A built-in delay to compensate for delay of the processing system under measurement is also provided.

For additional information write for Bulletin BA-102.

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JOHNSON

Dr. Richard M. Hurst: Appointed executive vice president of Textron, Inc.'s Bell Aerosystems Co. He will assume control and responsibility for direction of all operating activities of the company.

Donald A. Schultz: Appointed assistant corporate secretary of Milgo Electronic Corp. He will assume the duties of assistant corporate secretary in addition to his position as manager of the information services department.

Howard W. Johnson: Elected president of the Massachusetts Institute of Technology, succeeding **Julius A. Stratton.** Johnson has been dean of M.I.T.'s Alfred P. Sloan School of Management for the past six years.

Edward Offenhartz: Named deputy director, operational space systems, of Avco Corp.'s Research and Advanced Development Div. **John A. Dodge** has been appointed director, *Apollo* project office.

E. G. Shuster: Appointed division vice president, government marketing and electronic data processing, at Radio Corporation of America. He will be responsible for marketing RCA electronic data processing systems and equipment to federal, state and local government agencies.

Dr. E. Raymond Corey: Elected to the board of directors of Norton Co. He is the faculty chairman of the advanced management program at Harvard Business School.

Robert W. Byrne: Elected vice president of General Applied Science Laboratories, Inc. He will direct all GASL research activities.

Norman H. Peterson: Elected vice president-corporate services of the Timken Roller Bearing Co. Previously, he served as assistant to the president.

Donald B. Morse: Elected a director of the Aviation Distributors and Manufacturers Association. He is assistant general manager of the Scintilla Div. of the Bendix Corp.

Alan L. Rich: Appointed a member of the technical staff at Fairchild Space and Defense Systems. He will serve as a staff consultant in systems engineering.

David B. Nichinson: Elected to the board of governors of the Aerospace Industries Association of America for a one-year term. He is president of Kollsman Instrument Corp.

James D. Willson: Named corporate vice president-finance and chief financial officer of Northrop Corp. He is financial vice president of Tidewater Oil Co.

Kilbourne H. Knox: Appointed executive vice president of Weston Hydraulics, Ltd. He joined the company in 1956.

Thomas C. Ellis: Appointed executive vice president of the Airco Welding Products Div. of Air Reduction Co., Inc. He was formerly assistant to corporate president.

Howard A. Acheson, Jr.: Elected to the board of directors of Acheson Industries, Inc. He will continue as vice president of the company in charge of the operations of the Colloids Div.

Loyd R. McEachern: Appointed vice president of the American Monorail Co. He was formerly manager of the southeastern division.

J. Alan Stewart: Appointed vice president and general manager of the Battery Div. of Sonotone Corp. He will be responsible for the manufacture and distribution of nickel-cadmium batteries and cells.

R. Stanley Doebler: Appointed executive vice president of Argus, Inc. **John A. Lawler** was named vice president in charge of the Argus Optics Div.

Paul E. Warburgh: Named assistant vice president and administrative assistant at Project Fabrication Corp. He was cited recently as "The Engineer of the Year" by the Long Island Section of the American Institute of Chemical Engineers.

Dr. Arthur Aden: Elected a Fellow in the Institute of Electrical and Electronics Engineers. He was named to this rank "for contributions in the field of electromagnetic scattering and for leadership in research and development of devices and instrumentation for military and aerospace applications." He is vice president and manager of research and engineering of Electro-Optical Systems, Inc.

missiles and rockets
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JANUARY

Incentive Contracting Program, January 1966 Series, sponsored by the National Defense Education Institute, New York City, Jan. 10-14, Los Angeles, Jan. 17-21, Boston, Jan. 24-28.

Briefing on the Department of Defense Item Entry Control Program, sponsored by the Spares Provisioning Panel of the National Security Industrial Association's Maintenance Advisory Committee, Biltmore Hotel, Los Angeles, Jan. 13.

American Chemical Society National Winter Meeting, Phoenix, Ariz., Jan 16-21.

Society of Plastics Engineers Regional Technology Conference, sponsored by the Cleveland Section, Sheraton-Cleveland Hotel, Cleveland, Jan. 20.

Third Coral Gables Conference on Symmetry Principles at High Energy, sponsored by the University of Miami, Air Force Office of Scientific Research, Atomic Energy Commission, National Aeronautics & Space Administration, National Science Foundation, and Office of Naval Research, University of Miami, Coral Gables, Fla., Jan. 20-22.

Third Aerospace Sciences Meeting, sponsored by the American Institute of Aeronautics & Astronautics, New York City, Jan. 24-26.

National Symposium on Tests for Fire Resistance of Hydraulic Fluids and Lubricants, sponsored by the American Society for Testing and Materials, Jung Hotel, New Orleans, La., Jan. 24-25.

Symposium on Electrification of Machinery, sponsored by the Institute of Electrical & Electronics Engineers, Worcester Section, Wachesett Country Club, West Boylston, Mass., Jan. 25.

Engineering & Operations Workshop, sponsored by the American Public Power Assn., Roosevelt Hotel, New Orleans, La., Jan. 25-28.

1966 Annual Symposium on Reliability, co-sponsored by the American Society for Quality Control, Institute of Electrical and Electronics Engineers Reliability Group, the Institute of Environmental Sciences, and the Society for Nondestructive Testing, Sheraton-Palace Hotel, San Francisco, Jan. 25-27.

Seminar on Cosmology, sponsored by the American Institute of Physics and the National Association of Science Writers, Inc., New York Hilton Hotel, New York City, Jan. 25.

1966 Committee Week of the American Society for Testing and Materials, Shoreham and Sheraton Park Hotels, Washington, D.C., Jan. 30-Feb. 6

Winter Power Meeting, sponsored by the Institute of Electrical & Electronics Engineers, New York Statler-Hilton Hotel, New York City, Jan. 30-Feb. 4.

American Society of Civil Engineers Structural Engineering Conference, Fontainebleau Hotel, Miami Beach, Fla., Jan. 31-Feb. 4.

International Symposium on Information Theory, sponsored by the Institute of Electrical and Electronics Engineers, University of California, Los Angeles, Jan. 31-Feb. 3.

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The Downhill Path

ONCE AGAIN, the image of an efficient, cost-oriented Dept. of Defense so carefully painted by Secretary Robert S. McNamara has been tarnished by the use of defense contracts for political purposes.

The Administration's brazen use of defense contracts to fight the price increases of the steel industry carries this despicable practice a step beyond the Kennedy regime's efforts in the same direction.

President Kennedy used the threat of possible loss of contracts as a weapon when he fought the aerospace industry in 1962 on the union shop question. President Johnson turned that threat into reality when DOD actually ordered procurement officers to divert contracts from those companies that raised prices on structural steel.

It should be clearly understood that this was not merely a cost measure against purchase of the higher-priced brand. It applied to all contracts with those firms. It was made known that Bethlehem Steel stood to lose a multimillion-dollar ship-building contract on which it was the low bidder.

Secretary McNamara has emphasized time and again that the Defense Dept. now is run on a cost-effective not a political basis, a stand to which he has clung despite burned fingers on the controversial TFX contract.

Any remaining credibility to this contention vanished in the steel crisis. The question is not one of whether the desire to hold the line on steel prices is a laudable one; it is rather the willingness of the current occupant of the White House to use any expedient means to achieve that end, however damaging the means may be.

Certainly, with a war under way in Vietnam, all sentiment is on the side of the Administration. The temptation to shout, "Think of our boys who are fighting and dying; nail the profiteers to the wall," is well-nigh irresistible.

But it must be resisted. The Vietnam war is an undeclared war; there are no price controls. The steel companies are legally entitled to raise prices on their products if they wish to do so. The moral right is another question. But the President has at his disposal a number of means, particularly public opinion, to bring the companies into line. It should not be necessary to distort the proper functioning of the American free-enterprise system to do so.

The use of defense contracts for the purpose is an expediency which not only is a slander on all companies in the defense industry but which wipes away any belief in Secretary McNamara's quite proper efforts to establish the Pentagon as a bastion of quality and cost-effectiveness beyond the reach of politics.

If defense contracts can be used for this purpose, they also can be used for any other political purpose at the whim of the President.

This abuse of the defense contracting power should be of major concern to the aerospace industry and is, in fact, a direct outgrowth of the industry's abject failure to take a strong stand on the practice in the Kennedy union shop dispute.

It will be recalled that in 1962 President Kennedy was attempting to force a union shop vote on aerospace firms in a manner which even labor found unpalatable. When it came to a vote, workers at North American, Convair and Ryan turned it down one after the other. The late President in public statements had implied the companies involved might lose their defense contracts if they didn't knuckle under to the demand for a vote.

Of the entire industry, only Lockheed Aircraft faced up to the moral issues involved and made a fight of it. It was apparent that company management felt fundamental rights could not be sacrificed to the dollar sign, no matter what the cost.

A statement signed by Lockheed chairman Courtlandt Gross and president Dan Haughton had this to say:

"We believe that every employee should have the freedom to join or not to join a union, as he sees fit. We believe this is a basic American freedom—like freedom of worship and freedom of speech and freedom to take a new job or move to a new community—that must not be voted away."

Lockheed vice president John Canaday told newsmen: "We don't fear an election on the union shop issue. But if we sacrifice a principle, we no longer have a basis on which to stand." He described the firm's position as "a guard against erosion of fundamental rights."

Nor was Lockheed afraid to face up to the contract threat. Chairman Gross called the President's statements "not in the public interest."

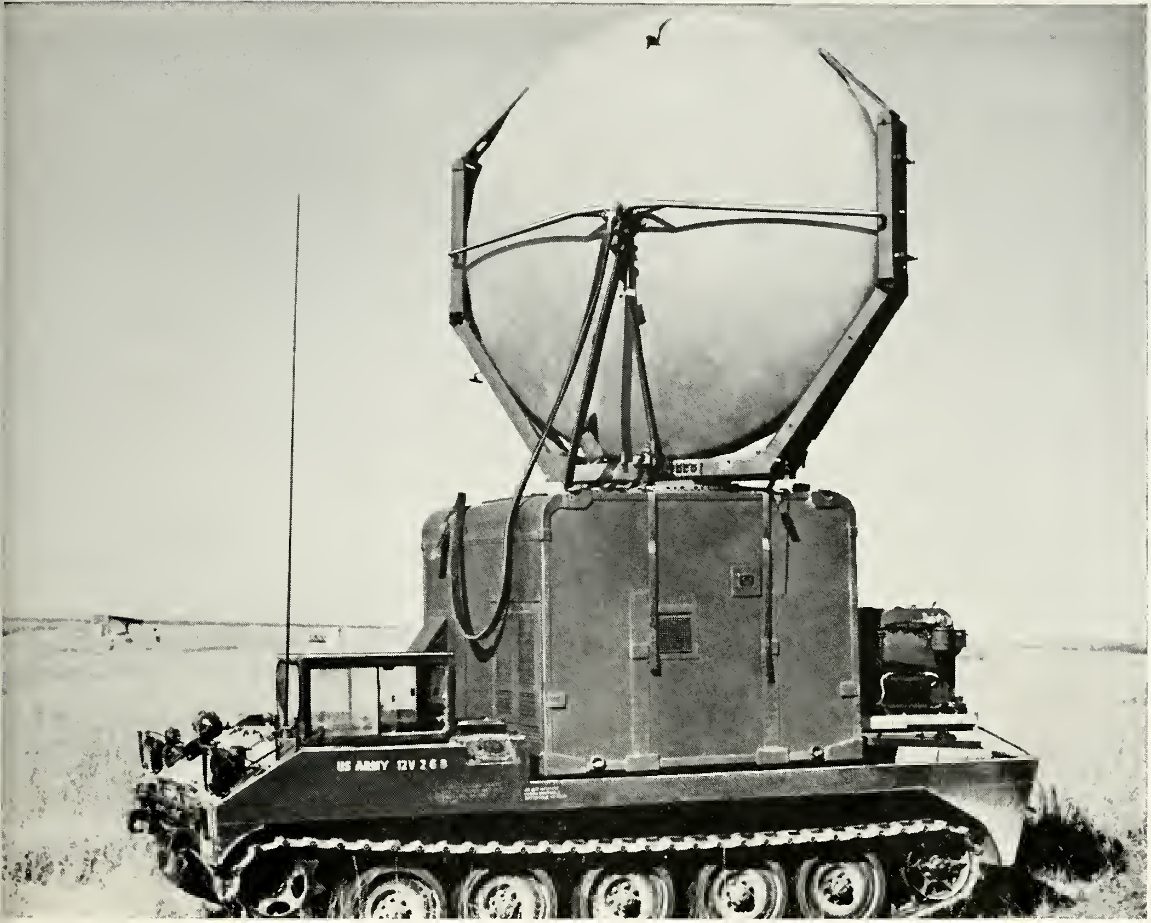
LOCKHEED STOOD ALONE in that battle. It survived a strike and it survived the threat of withdrawal of its government contracts. When the dust settled, there was no union shop at Lockheed and the company remains today as one of the nation's leading defense contractors.

But where was the remainder of the industry while Lockheed was fighting these fundamental battles? It was busy side-stepping the President's line of fire, taking the expedient path. We suggested at the time that the failure to present a united front against the Administration's abuse of its contracting power would lead to further government control of the industry.

That next step now has been taken in the steel dispute. Whether the Pentagon's statement on withdrawal of defense contracts played a part in the steel industry's decision to back off the $5 a ton increase is immaterial. The abuse of defense contracting powers is very material.

That abuse should be strongly protested by the industry. But, with one exception, we have seen no indication it has either the foresight or the courage to face up to the issue.

William J. Coughlin



Our Armed Forces in Southeast Asia and in other corners of the world are now using the AN/TRC-80, originally designed for use with the Pershing Missile System, for point-to-point tactical communications. It provides one duplex voice channel and one half-duplex teletype channel. It can be put into full operation by a two-man crew within 10 minutes of its arrival by helicopter or land transport.

Varian Klystrons Still Operating in Southeast Asia as of August 26, 1965

SERIAL NO.	OPERATING HRS.	SERIAL NO.	OPERATING HRS.
1564	7,290	1051	16,447
1225	20,520	1572	14,786
1371	5,278	1291	14,044
1039	22,798	1101	17,251
1097	20,286	1582	18,064
1230	5,890	1515	11,281
1014	11,233	1506	11,658
1585	10,288	1393	3,909
1229	4,368	1522	9,160
1087	22,630	1440	10,092
1103	6,920	1352	8,394
1211	20,400	1402	6,224
1092	19,820	1373	11,791

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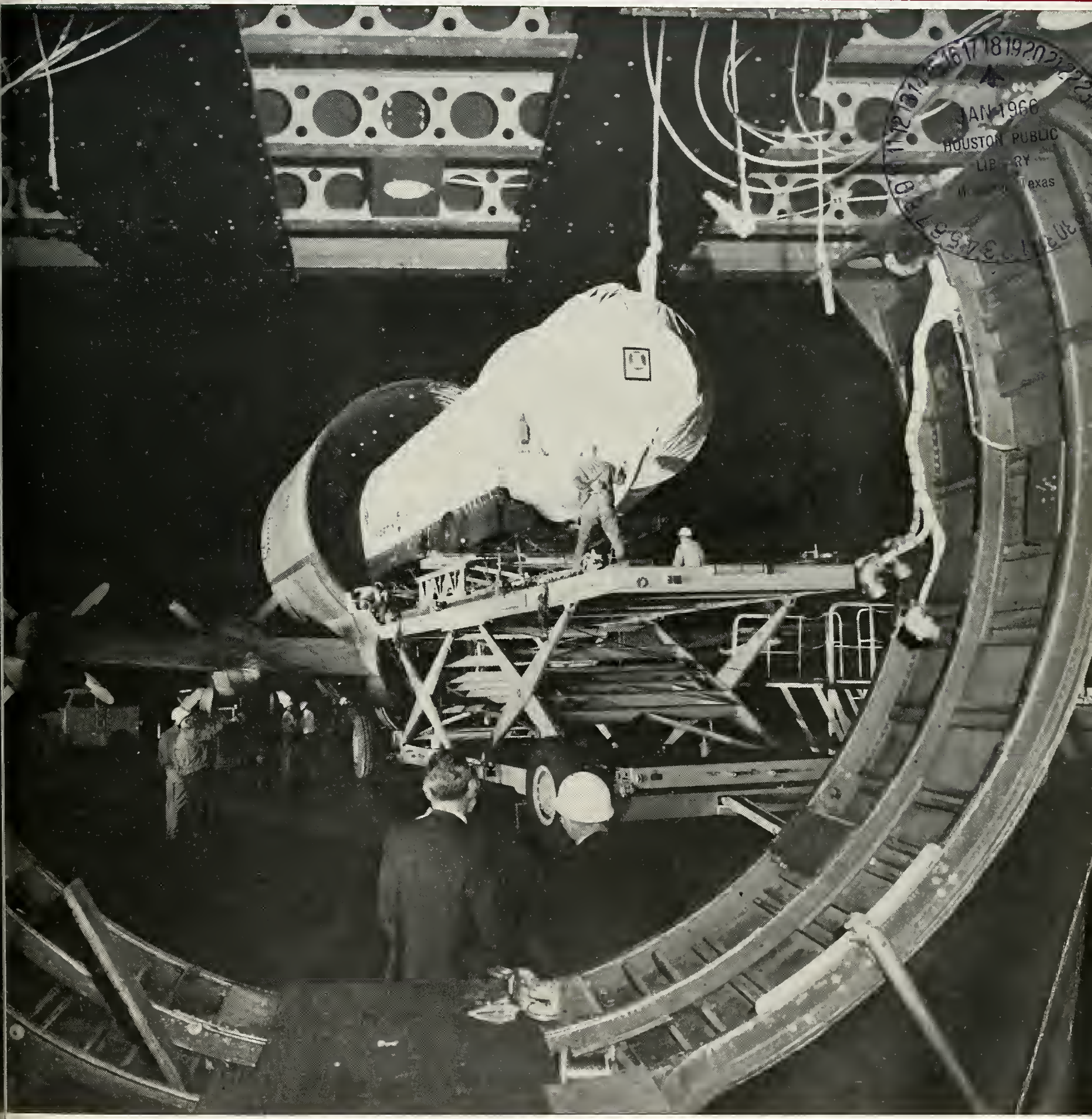
JANUARY 17, 1966

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY



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Gemini 8 Booster Unloaded from Pregnant Guppy at Cape

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UNITED STATES

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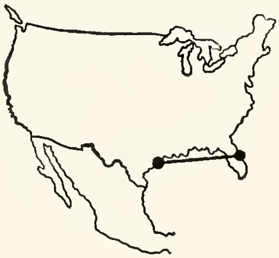

The Cape Kennedy-Houston GLDS is part of a 225,000-mile global tracking and communications network used by NASA to control space missions. It is another example of the vital role communications play in the progress of space exploration.

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missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 18, Number 3 January 17, 1966

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THE COVER

Titan launch vehicle to be used in the Gemini 8 flight being unloaded from the Aero Spacelines "Pregnant Guppy." Gemini 8, along with all other remaining flights in the program, could have its time in orbit lengthened to three days to allow more rendezvous, EVA flexibility. See p. 16.

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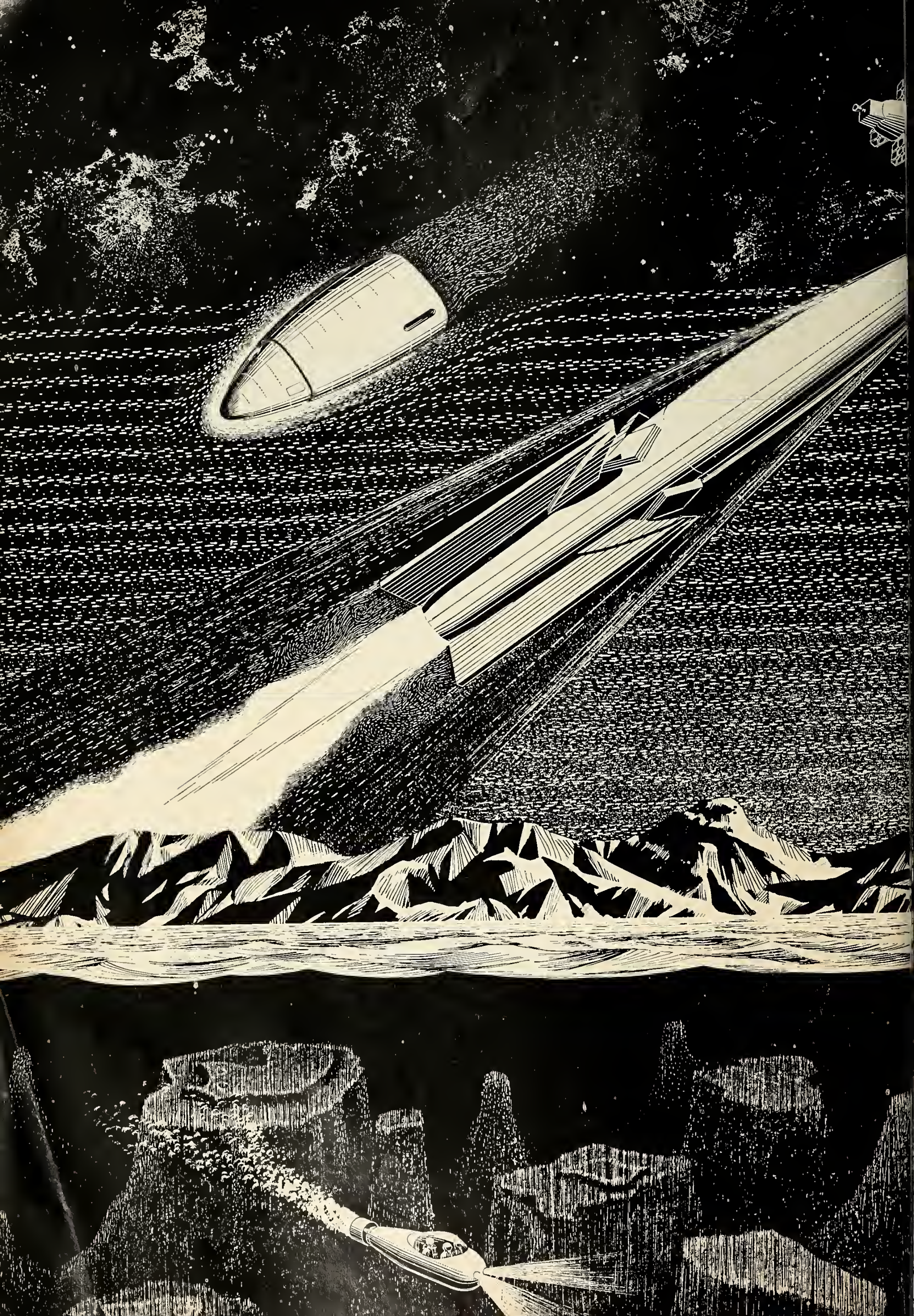

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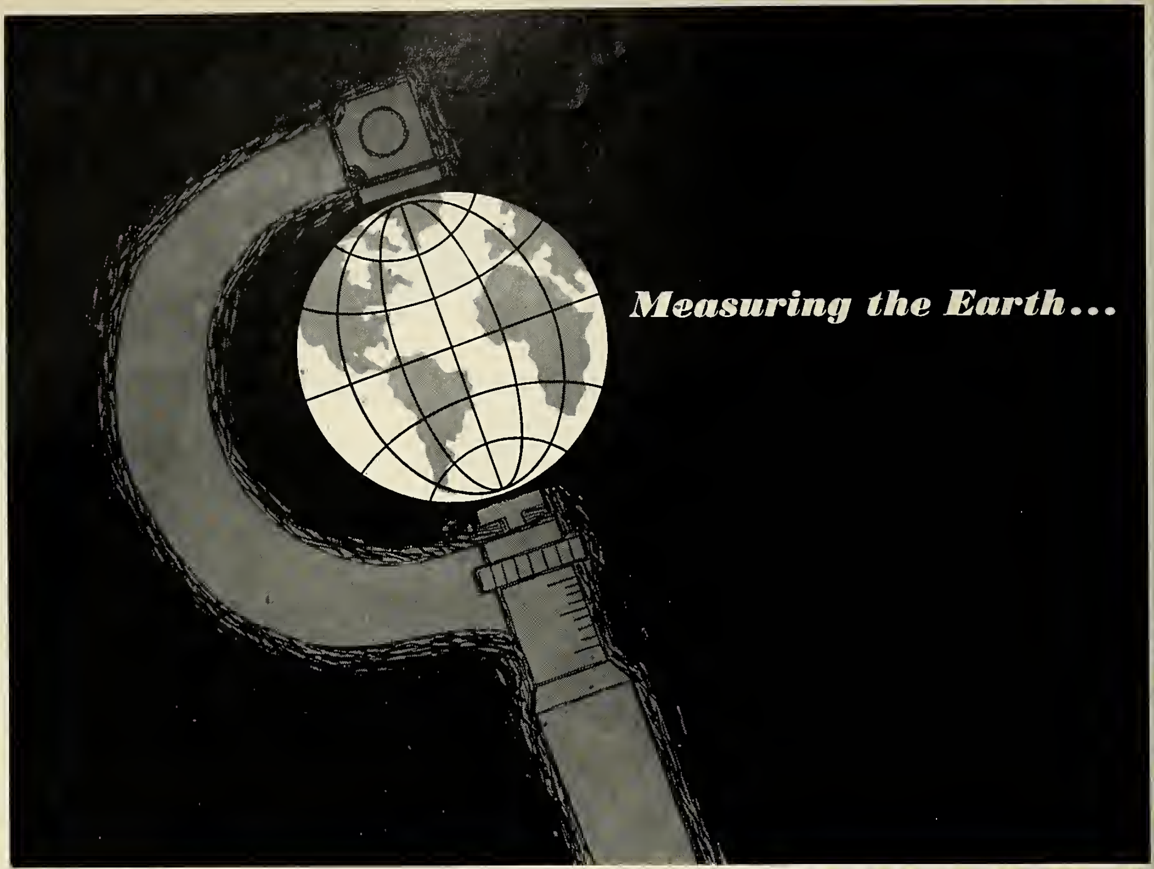
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- Acoustic properties of the ocean
- Three-dimensional tracking systems
- Military missions in space
- Building on the ocean floor
- Digital control system techniques
- Miniaturized telemetry development
- Nuclear explosion warning systems
- Computerizing recruit assignments
- Testing the Poseidon Weapon System
- Supersonic water entry shock environment
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letters

Lewis at Quarter-Century

To the Editor:

On Jan. 23, 1966, the Lewis Research Center will complete 25 years of aeronautical and space research and development work since ground was broken for our first facility in 1941.

Anniversaries as such can be pretty dull, but we thought you might be interested in mentioning this fact. Lewis has done some fairly exciting and significant work over the years, and we have a large family of ex-Lewis people situated in important positions throughout the industry.

Lynn Manley
Chief, Public Information
Lewis Research Center
National Aeronautics
and Space Administration
Cleveland, Ohio.

TRW Role in STAFF

To the Editor:

In the Nov. 22 M/R you had a very interesting article on the success of the STAFF program. The photograph on the cover of the magazine depicted the last and most successful firing of the program. Of particular concern to me and a number of people at TRW Systems has been the complete lack of recognition of our effort in the program.

TRW Systems was under contract to General Precision, Incorporated, for the design, fabrication and development of the Special Test Vehicle (STV) which replaced the warhead on the *Polaris* missile in this test program. In addition, TRW designed the tracking, telemetry and instrumentation systems, the ground support equipment; planned the trajectories, the flight test plan and designed the post-flight evaluation system.

This program was under the direction of John W. Bozeman; Assistant Director Will A. Finley was responsible for the technical direction of the program. It is a shame that the efforts of these people to produce a system on schedule and within the cost estimates have gone unrecognized.

Jack M. Cherne
Project Engineer
Engineering Design
LEM Descent Engine
(Formerly Project Engineer
Engineering Design
Polaris STV)
TRW Inc.
Redondo Beach, Calif.

Hogwash/Pugwash

To the Editor:

The views of Mr. V. L. Coffield and Co. (Letters, M/R, Dec. 20, p. 6) notwithstanding, all your sane and patriotic readers will remain faithful subscribers to MISSILES AND ROCKETS. The few you may lose are well worth getting rid of. I consider your Dec. 6 editorial a masterpiece of clear and rational thinking. Please keep up the good work. There are mighty few publications these days that have the editorial staffs willing to stand up to the "better red than dead" creeps who seem to be pervading our society.

Do you have a lifetime subscription?

Theodore A. George
Arlington, Va.

Oops! Dept.

To the Editor:

At the Manned Spacecraft Center, as well as many places in industry, your magazine is highly regarded. However, the article on page 28 of the Nov. 29 issue, "Apollo 009 Static-Fired," represents a low point in your reporting accuracy.

There are three obvious errors that should be brought to your readers' attention:

(1) The static firing was for 15 + seconds—not 20 minutes (get serious).

(2) The fact is, despite the Kennedy Space Center timing system failure, ACE-S/C was able to send commands manually to start and stop the firing (where do you get your information?).

(3) Your statement that the ACE-S/C computer operates in "plus time only" is misleading in that the computer operates in minus time (relative to firing) and plus time.

The article might have read:

"The Service Propulsion System for S/C 009 was static-fired at Kennedy Space Center on Nov. 19, utilizing ACE. Even though there was a malfunction in the range timing system, the engines were turned off successfully by utilization of ACE in the manual mode. This is the first time that an ACE-S/C ground station has controlled a static-firing sequence. The RCA timing at KSC failed at T-O. Without proper timing the ACE-S/C computer was not able to automatically gimbal the SPS engines; therefore, manual mode of ACE control was utilized for shutdown. The capability to gimbal the SPS engines from the ACE-S/C ground station had previously been demonstrated during a dry run."

John K. Patterson
ACE-S/C Computer Engineer
NASA-MSC (EB5)
Houston, Tex.

It was a combination of information lag and last-minute gremlins.—Ed.

Reprints of M/R Index

Reprints of the editorial index of articles appearing in MISSILES AND ROCKETS during the last six months of 1965 are available at no cost from:

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The Countdown

WASHINGTON

Thumbs Down on Nike-X Production

Army has received official word from the Secretary of Defense that there will be no production of *Nike-X* during Fiscal 1967. The program is expected to continue, however, at about the same high level of research and development—which in FY '66 came to about $400 million. Behind the decision, according to informed Dept. of Defense officials, is the continuing question of whether *Nike-X* represents the best alternative among several damage-limitation strategies. DOD insists the decision against initiating production of the anti-ballistic missile system is not tied to rising Vietnam war costs and that it is not a unilateral disarmament concession to the Soviet Union.

Chinese Subs Seen as Earliest Threat

Dept. of Defense officials believe the emerging Communist Chinese nuclear threat may arrive first in the form of submarine-launched low-altitude cruise missiles. Best defensive strategy therefore may be in the area of anti-submarine warfare. This is another factor in the decision against *Nike-X* production at this time.

Vandenberg MOL Rumor Discounted

Air Force spokesmen say there is no truth to rumors at Cape Kennedy that the budget squeeze on the *Manned Orbiting Laboratory* (*MOL*) (M/R, Dec. 13, p. 7) will upset launch complex construction at Vandenberg AFB, resulting in an increase in the number of launches planned from the Cape. Speculation was that the Air Force had agreed to accept some polar orbit or payload weight restrictions rather than delay the entire program. This was denied. Air Force says, however, that it still plans to launch at least the first one or two *MOL* flights from the Cape, beginning late this year (M/R, Jan. 3, p. 7).

Patrick AFB Support Report Ready

A report by a special investigating subcommittee into the question of whether a support service contract at Patrick AFB, Fla., should have been handled by Pan American Airways or military personnel now is in the hands of the House Armed Services Committee chairman. It was drawn up following a series of hearings last year. Insiders say the committee will not take a strong stand on what the Air Force decision in the case should have been.

How Do You Shake Hands with Moon Dust?

NASA's Manned Spacecraft Center is asking industry for proposals on the prototype of a glove system for handling lunar samples returned by *Apollo* missions. Proposals are due Jan. 20. MSC says specimens from the Moon probably will be brought back in stainless-steel containers with a weight of from 35 to 40 lbs. Two such containers will be returned from the first lunar landing.

Mystery of the Unplugged Plug

Sources at Cape Kennedy now give this explanation for the loose electrical plug which fouled the Dec. 12 *Gemini 6* launch attempt: after the electrical crew connected the plug, a mechanical crew moved in to connect its lanyard to the pad. In the course of this, the plug was disconnected from the booster, then connected again—but without giving it a turn to secure it. Hereafter, the electrical crew will make a final check after the mechanical crew completes its operation.

NASA Checks Out Apollo Homers

Check-out tests of direction-finding equipment to be used for homing on the *Apollo* vehicle after re-entry into the Earth's atmosphere have been completed at the Manned Spacecraft Center in Houston. The AN/ARD 17 type VHF/S-Band direction receivers will be aboard Air Force HC-130H air rescue aircraft dispersed along the *Apollo* landing footprint.

INDUSTRY

UTC Awaits New 120-in. Awards

United Technology Center still is awaiting further contracts for its 120-in. solid motor. Two 120-in. programs are planned, but neither has been given the go-ahead. One is for the seven-segment motor to be used in West Coast launches of the *Manned Orbiting Laboratory*. The other is for a two, or possibly three, segment strap-on for *Titan III-D*. Meanwhile, UTC has been forced to lay off another 200 workers. This brings employment down to less than 1,500 from 3,100 some 18 months ago.

Varian Confirms GE Purchase

Varian Associates has confirmed reports of purchase of General Electric's Microwave Tube Laboratory at Palo Alto, Calif., for a price of approximately $1.5 million. Company officials expect the acquisition to strengthen Varian's line of traveling wave tubes and associated equipment. Little change is expected in management of the GE laboratory, which will operate as a unit of Varian's Tube Div.

INTERNATIONAL

Japanese Take Up Humphrey Offer

A proposal by Vice President Hubert Humphrey during his recent trip to the Far East that Japan join the U.S. in an international space effort is being actively explored by the Japanese government. Talks with U.S. Embassy personnel in Tokyo have been followed by proposals to NASA and the State Dept. in Washington. No disclosure of the nature of the discussion has yet been made.

Watch Out for That Last Step!

NASA publicists still have a lot to learn about sugar-coating unpalatable space failures, as demonstrated by this Soviet report on the unsuccessful *Luna-8* attempt to soft-land a space vehicle on the Moon: "During the approach to the Moon, a comprehensive check was conducted on the functioning of the systems ensuring a soft landing. The check showed that all the station's systems functioned normally during all stages of the landing on the Moon except the last stage."

Japanese Show Comsat Equipment

A computerized system of handling calls via satellite has been demonstrated in Tokyo by Nippon Electric Co. The system, developed with Hughes Aircraft, is known as STAR (Satellite Telecommunications with Automatic Routing). A multiple-access mode permits a number of Earth terminals to select and call other stations, and send and receive speech, data or TV pictures through satellites.

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The Missile/Space Week

DOD Request Is $58.3 Billion

President Johnson has asked Congress for a Fiscal Year 1967 defense budget of $58.3 billion, a $4.1-billion increase over the FY '66 budget, to press the war in Vietnam "as long as aggression commands us to battle."

In his State of the Union address Jan. 12, the President said that he would continue his efforts to achieve an acceptable peace in the conflict, but declared repeatedly that the U.S. would remain in Vietnam as long as necessary to meet its commitments.

The $58.3-billion request for military funding was slightly more than half of the total FY '67 budget request of $112.8 billion. An additional defense request of $12-13 billion is expected to go to Congress shortly in the form of a supplement to the FY '66 budget.

Overhaul of NSF Urged

An expansion of the role of the National Science Foundation giving it a program administration comparable to those of NASA and the Atomic Energy Commission has been recommended by the House Space Committee's science, research and development subcommittee.

The subcommittee report urged an overhaul of the foundation, indicating it was inadequate for its present and future roles. The report also indicated it expected NSF to move into support of large-scale undertakings for basic research although present plans for the future of "big science" seem vague.

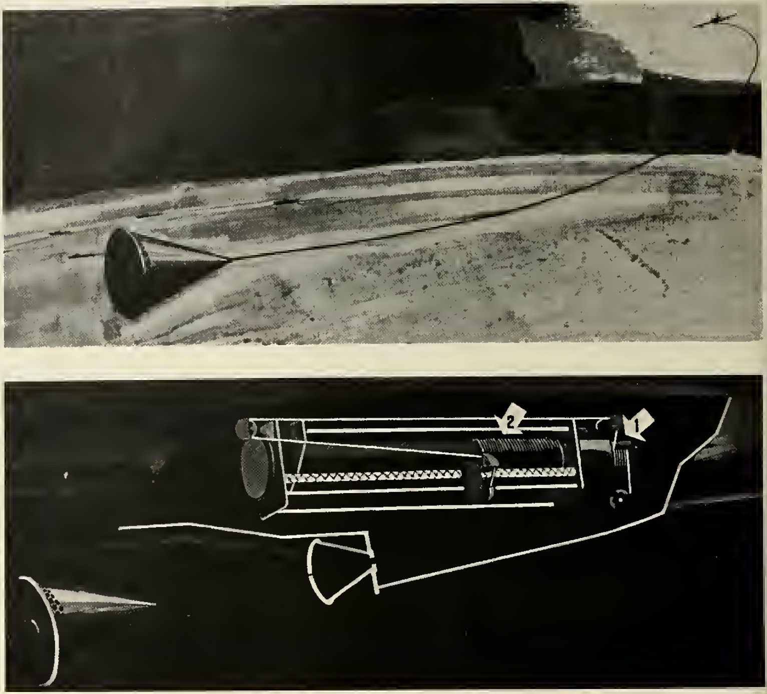
Legislation to improve the position of the foundation may be introduced this session, the report suggested.

Aerojet Fires Sprint Motor

A full-scale solid rocket motor being developed for use on the *Sprint* anti-missile missile has been successfully test-fired by Aerojet-General Corp.

The Dec. 17 test was the first of two scheduled motor firings using a composite class 2 propellant. The motors use a glass filament wound *Sprint* first-stage chamber. The second firing is planned for the near future, company officials said.

The Aerojet work is being done under a $499,403 award from the *Nike-X* Project Office at Redstone Arsenal, Ala. The nine-month contract was awarded Aug. 12.



Airborne Command Post Antenna Design Shown

The Air Force has awarded Collins Radio Co. a $3 million contract for antennas capable of being extended several thousand feet and retracted in flight. The 437V-1A antennas will be used on Air Force airborne command posts. Designed for transmission in the VLF and LF ranges, the Collins-built antenna is part of a system including a transmitter and coupler. Drawing above shows 1) the capstan mechanism that hydraulically extends or retracts the wire and 2) the reel on which the copper-wound steel wire is stored. The entire system is tucked in the fuselage just under the aircraft's wing in an insulated box not shown here. The wire's cone-shaped stabilizing drogue, two feet across, is visible in both views.

Senate Space Hearings Set

The Senate Space Committee will hold hearings on the national communications satellite program as conducted by NASA and the Dept. of Defense on Jan. 25 and 26.

The sessions will inquire into NASA and DOD's relationship with other government agencies and the Communications Satellite Corp.

Other hearings scheduled include the nomination of Robert C. Seamans, Jr., to deputy director of NASA (no date set) and NASA authorization for Fiscal 1967 (Feb. 28 to Mar. 4).

The committee plans to conduct hearings on national goals for aeronautical and research development sometime in April.

Goddard Library Funds Pledged

More than $1.5 million has been pledged to the Robert Hutchings Goddard Library program at Clark University, Worcester, Mass.

Of that total, $700,000 has been promised by aerospace corporations, according to J. Leland Atwood, president of North American Aviation, Inc., and general chairman of the program. The gifts total almost 30% of the $5.4 million needed to build and endow the Goddard library.

Shots of the Week

A secret Air Force satellite was launched Jan. 7 from Vandenberg AFB, Calif., aboard a *Thor-Altair* rocket. The shot was an apparent success; no details were released.

- *Cosmos 104* was launched Jan. 7 by the Soviet Union for continued space research. Orbital parameters were an apogee of 401 km, perigee of 204 km, inclination of 65 degrees and period of 90.2 min.

- Final launch of a series of *Nike-Apache* sounding rockets failed Jan. 10 when the telemetry signal was lost one minute after liftoff. The 51-lb. payload was launched from Wallops Island, Va., reached a peak altitude of 115 mi. and impacted 88 mi. downrange. The sounding rocket series was sponsored by NASA, the University of Illinois, and GCA Corp.

DOD Council Members Named

Six new members have been named to the Defense Industry Advisory Council by Cyrus R. Vance, deputy secretary of defense and chairman of the council.

They are: Fred J. Borch, president, General Electric Co.; Kermit Gordon, vice president of Brookings Institution; Daniel J. Haughton, president, Lockheed Aircraft Corp.; Donald A. Holden, president, Newport News Shipbuilding and Drydock Co.; Roger Lewis, president, General Dynamics Corp.; and Noel B. McLean, board chairman, EDO Corp.

Manned Transport Pacts Let

Two contracts for continued engineering studies relating to a manned reusable space transport system have been awarded Lockheed-California Co. and Martin Marietta Corp. by Marshall Space Flight Center.

Lockheed will study alternate routes available for the system's development as an extension of presently approved launch and space vehicles. The nine-month contract is for $237,000.

Martin will carry out a comparison study of launch modes under a six-month, $51,000 award.

Israeli Missile Buy Denied

Both French and Israeli officials have denied published reports that the Israeli government plans to buy 30 medium-range ballistic missiles from France.

It had been reported that the two nations had entered into a secret agreement under which France would provide the missiles, believed to be a military version of the *Diamant* booster.

A French government official said that private French companies have been authorized to provide "technical cooperation" to Israel on military missile development. A foreign ministry spokesman in Jerusalem confirmed the French statement, limiting France's role to that of technical adviser.

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Apollo Applications RFP Due This Week

Issuance follows Administration approval of NASA budget request of some $5.125 billion; AAP funding in FY '67 seen under $100 million

by Hal Taylor

APPROVAL of a Fiscal Year 1967 budget request of about $5.125 billion has cleared the way for the issuance of a request for proposals for systems definition of the *Apollo* Applications Program.

The RFP—which was scheduled to be mailed by the Marshall Space Flight Center on Jan. 14—should reach industry this week.

It will call for about a six-month systems definition period in which two to four firms will be selected for parallel contracts. Later, one of the firms will be named as the program's prime contractor.

Funding for the program in the next fiscal year is expected to be under $100 million.

Together with the approximately $50 million which the Office of Manned Spaceflight had available for the program this year, the funds probably will be used only to pay for those experiments which can be performed in Command and Service Modules left over from Project *Apollo*. Mainly, this will consist of spacecraft not used in achieving the basic goal of the *Apollo* program—the first manned landing on the Moon.

Most industry officials believe that the meaty part of the program—extended flights in Earth orbit up to 45 days, lunar surface missions lasting 14 days and 28 days in lunar orbit—will not be funded in terms of hardware until Fiscal Year 1968.

The FY '66 and '67 funds, however, will pay for the final definition and design of the spacecraft and experiments for the long-duration flights—not scheduled to be flown until 1970.

Space station unlikely—It is also possible, but not probable, that the space agency in 1968 may decide to scrap the long-duration missions and instead build a true space station with an orbiting capability of a year or more. This is not considered likely, because NASA traditionally has attempted to increase the orbital lifetime of its various spacecraft programs gradually.

For example, it moved from one day in the *Mercury* program to 14 days in the *Gemini* program to 30 days in the *Apollo* program. It is considered unlikely that a jump from 30 days to one year would be approved.

It is far more likely that NASA will approve the AAP flights—which will last 45 days and ultimately more than 100 days—before proceeding with development of a space station.

It is also highly unlikely that the agency would approve the very expensive space station project as early as FY '68, because the cost of Project *Apollo* will still be at a relatively high level. It will be even less likely if the Vietnam war is escalated.

Austerity—The $5.125-billion total for the space agency is far below its requested $5.6 billion. It is also below the request for the current year, which was $5.26 billion. Ultimately, Congress trimmed this to a total authorization $5.19 billion and an appropriation of $5.175 billion.

Many missile/space industry firms are expected to submit bids for the upcoming RFP, which covers definition of the scope of the entire AAP program including the desired number of flights, what experiment should be flown and how the experiments and the spacecraft can be integrated for the best results.

TRW Systems Group is expected to submit a bid for the prime contract, with Chrysler Corp. and the Northrop Corp. as part of its team.

IBM is another firm which is bidding for the top job with the Boeing Co. as part of its team.

Three other firms—General Dynamics, Lockheed Aircraft Corp. and the Martin Co.—have also indicated readiness to join the competition, although the first two are not expected to join teams. Martin indicated only that it would submit a bid and would not say if it would be as part of a team.

New booster studies—In a development related to future spacecraft programs, Marshall Space Flight Center announced that it is awarding five new contracts to study improving the *Saturn IB* and the *Saturn V* boosters—as well as development of an intermediate booster with a payload capability somewhere between the two launch vehicles.

Both the *Apollo* Applications spacecraft and the space station would be launched into orbit by the boosters.

On *Saturn V*, Boeing Co., first-stage (S-IC) contractor, was awarded contracts worth $370,500; North American Aviation, second-stage (S-II) contractor, got an award worth $329,624; and Douglas Aircraft, third-stage (S-IVB) contractor, received a total of $96,730.

In the *Saturn IB* area, Chrysler Corp., prime contractor for the first stage (S-IB), received the prime contract for improvement studies, amounting to $450,000. Douglas, second-stage (S-IVB) contractor, received a $116,345 pact for supporting the study effort. Six *Saturn IB* configurations will be studied.

In the *Saturn IB* studies, the first of six concepts to be investigated in detail uses a "zero stage" for launch. This consists of four 120-in. solid-propellant rocket motors strapped to the S-IB stage.

The zero stage would launch the vehicle and boost it to altitude. The first stage, an S-IB liquid-propellant unit powered by eight H-1 engines, would ignite at zero-stage burnout. The second stage would be an S-IVB.

The second configuration consists of an S-IB stage with only four H-1 engines but with four 120-in. solid motors attached. All engines, solid and liquid, would ignite for launch. The second stage would be an S-IVB.

The third concept would consist of an S-IB with all eight H-1 engines and two 120-in. solids attached, all igniting for launch. The second stage again would be an S-IVB.

The fourth concept would consist of the *Saturn IB* vehicle with four *Minuteman* solid-propellant motors attached to the S-IB stage.

The fifth concept would be essentially the same as the fourth but with eight *Minuteman* motors strapped to the booster instead of four.

The final configuration to be considered features as the booster a cluster of five 120-in. solid motors. Douglas will conduct this study as system analysis study contractor, whereas Chrysler was named prime contractor for the first five concepts and Douglas was named to provide support.

In between—One of the eight variations to be considered under the *Saturn V* contract is an intermediate vehicle consisting of modified S-II and S-IVB stages powered by a new type of liquid oxygen engine. It would be launched at existing *Saturn V* facilities from an elevated platform the same height as the missing S-IC stage. ■

McNamara Methods Arousing Fresh Criticism in Congress

by Michael Getler

Secretary of Defense Robert S. McNamara, defending his policies and his department's budget this year before Congress, will face a legislative body which is becoming increasingly critical of many recent DOD decisions and of the relationship which now exists between the DOD and the Congress.

A sampling of Congressional opinion regarding the secretary's recent actions conveys "more concern and worry" with the manner in which he has chosen to do things than with the acts themselves.

Last week, prior to the submission of the FY '66 supplemental appropriation, McNamara was sharply criticized by Rep. L. Mendel Rivers (D.-S.C.), chairman of the House Armed Services Committee, for several actions taken while Congress was not in session, and allegedly with no prior notification to Congress.

Rivers convened his committee Jan. 11 in an unusually early session and ordered four subcommittees set up to gather data on specific actions already taken by the Secretary. Purpose is to better prepare the committee for actual authorization hearings later in the session.

The subcommittees will look into defense R&D, the B-52 bomber cutback and the related question of the B-111's effectiveness as a replacement, the string of base closings announced last month, and the announced deferral of several military housing construction projects. The subcommittee investigating the construction situation will also develop material regarding use of DOD metal stockpiles to control prices.

Hearings of the bomber subcommittee are expected to start Jan. 24. Other committees will probably begin even earlier. Reports to the full committee are expected around Feb. 22.

In establishing these committees, Rivers had some sharp words for each area. Regarding deferral of the already approved construction programs, Rivers said, "we are not going to go through another exercise in futility on enacting authorization bills after long and serious consideration, whether they be military hardware or construction, only to have projects deleted or deferred without even advising the representatives of the American people."

Rivers said he "was completely dumbfounded by the fact that without any prior consultation with Congress, the secretary announced deferment of many important items and all military family housing."

Regarding the B-52 phase-out, Rivers said that "the testimony of the Secretary of Defense last February and the action of the secretary last November are at such complete variance that the committee must be fully informed on our plans for our future capability in manned bombers."

Rivers summed up what may well be a prevailing mood among the military committees of Congress: "The Congress and the DOD must act as partners in the matter of national security, but I think there are times when DOD forgets that the Congress exists for reasons other than to provide a blank check."

What perplexes some Congressmen even more is why McNamara chooses to alienate members of Congress, who are not necessarily at odds with the decisions he has come to, by not taking the time to consult or at least inform them prior to making public announcements.

Earlier this month, McNamara was the target of a sharp attack by Rep. Craig Hosmer (R-Calif.) in the congressman's report to the House GOP Conference.

Hosmer accused the secretary of more than a dozen "questionable judgments" in the past five years. He said, for example, that the B-52/B-58 bomber cutback will reduce our strategic megatonnage in 1971 "to 71% of what it is today," an argument which proved hard to defend when advanced by former Senator Barry Goldwater. He also accused the secretary of faulty judgment on Vietnam, on the TFX aircraft decision, on retirement from the U.S. stockpile of 24-megaton bombs, on redeployment of tactical nuclear weapons in Europe, on insistence on keeping the *Nike-X* in R&D, and of his "habitual and profligate misuse of 'numbers game' techniques which deceive himself and result in misstatement of defense capabilities." ■

Decision on Titan Launch Expected

AN AIR FORCE decision is expected within the next two weeks regarding the future launch schedule of the *Titan III-C.*

The booster's third stage—the Transtage—and attitude-control system (ACS) have both experienced malfunctions in the past two flights which have resulted in failure of the launch vehicle to complete those missions that come close to demonstrating *Titan's* full capability (M/R, Jan. 3, p. 14).

Both failures have occurred in the final phase of the mission, when the Transtage was to place payloads into a near-synchronous altitude (18,200 n. mi.) orbit.

The most recent failure, during the Dec. 21 flight, has now been traced to faulty valve operation associated with operation of the N5 rocket in the Transtage ACS.

The valve, according to the Air Force, leaked either fuel or oxidizer, resulting in complete loss of one of these fluids. The ACS then became inoperative, causing the stage to tumble and rendering the guidance system ineffective. As of late last week, the Air Force still had not pinpointed the cause of the valve failure.

During the past week, *Titan III-C* program officials met on the West Coast to attempt to determine the extent of the *Titan's* problems and generate a recommendation regarding the next scheduled launch, which is to place the first eight satellites of the Initial Defense Satellite Communications Program into the same 18,200-n. mi. orbit. The flight was originally set for mid-March.

While the Air Force recommendation is still awaited, sources close to the IDSCP program told MISSILES AND ROCKETS that it is "probably not wise to gamble with the entire IDSCP payload until a complete success has been achieved, including the near-synchronous altitude maneuver." This involves the transfer by the Transtage from Earth orbit to the 18,200-n. mi. altitude and circularization of the orbit at that altitude with a change in the orbital plane of about 26 degrees to a position over the equator.

Program sources say a compromise solution may be reached involving use of a laboratory qualification model of the IDSCP satellite dispenser aboard the next *Titan III-C*, carrying perhaps a smaller number of satellites. It is still expected that the launch will come this spring.

Rendezvous, EVA Conditions May Extend Gemini Flights

by Jinx Mercer

STAYTIME IN ORBIT for remaining *Gemini* missions may be stretched to three days to accommodate several rendezvous attempts and extended extravehicular operation during each flight.

Charles W. Mathews, *Gemini* program manager, says subsequent flights will emphasize a number of primary activities, rather than a single main objective as in previous flights.

"On the next flight, for example, we are planning a rendezvous that is similar to that during *Gemini 6,* an attempt to re-rendezvous using back-up methods, and a rather extended extravehicular activity (EVA), which will last for one full orbit.

All remaining *Gemini* spacecraft will carry fuel cells, he said. This greater ampere hour capability can be translated into either a longer staytime in orbit or longer operations under high load conditions. But he added: "I don't think we will stay up longer than three days." He pointed out that the limiting factor is the cryogenics storage tankage, which is purposely designed smaller on rendezvous-configured spacecraft to make room for more fuel.

New data—In an interview with Missiles and Rockets, Mathews also revealed that:

—Studies are under way to protect spacecraft windows from exit heating deposits.

—Astronauts will still attempt to find stars in the day side of the orbit.

—Plans to retrieve micrometeoroid plates from *Pegasus* satellites are proving impractical.

The decision whether to use the Alternate Target Docking Adapter (ATDA) in place of an *Agena* on the *Gemini 8* mission may not be made until mid-February.

In discussing plans to protect the spacecraft windows during subsequent *Gemini* flights, Mathews said, "we had felt up until now that the window problem was not severe but from comments made from *Gemini 7/6* pilots, we now feel that it might be worthwhile to protect the windows." Depositing on the windows has been reported to occur during the exit heating portion of powered flight.

He said NASA was considering transparent, plastic covers able to withstand high temperatures and that these would be jettisoned by a spring-operated device coupled with a timer, or would be pulled back against the sides of the spacecraft in orbit. "Both Manned Spacecraft Center and McDonnell Aircraft Corp. engineers are looking into this," he said. "However, it may not be practical to include such a modification on the *Gemini 8* spacecraft."

Plans also now call for the astronaut emerging from the spacecraft during EVA to wipe the windows clean. "This is not only to get the windows clean, but to bring back better information on the window material itself." EVA during the *Gemini 8* mission is scheduled for the morning of the second day.

Star seeking continues—The *Gemini* program manager also is unconvinced that stars cannot be seen in the daytime. "We have not given up on the ability to do this," he said, adding that astronauts will continue to look for stars during future *Gemini* missions.

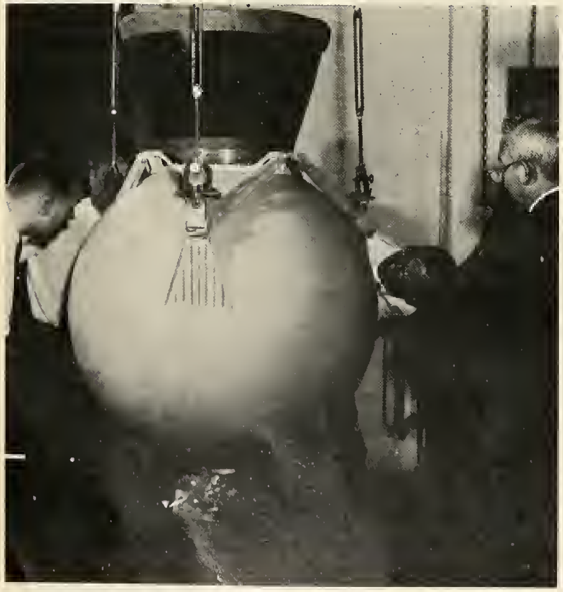
Mathews said Pegasus panel retrieval does not appear too practicable now primarily because the *Pegasus* has not decayed sufficiently in its orbit. "We thought it would come down to around 220 n. mi." He said going after it in its present orbit—around 270 n. mi.—would require modifying the spacecraft to augment its retro-fire capability and that program officials were not prepared to do this now.

Astronauts can ride up to an altitude "slightly higher than 200 n. mi." using the *Agena* main propulsion system, he said. But in any such operation contemplated, "we have to have more than one way of getting down." This requires budgeting sufficient orbital attitude and maneuvering system fuel to allow the transfer down from high altitude strictly on spacecraft power. With present fuel capacity onboard the spacecraft, excursion with the *Agena* to a 270-mi. altitude is impossible.

Agena fix—Tests on the *Agena* main engines at the Tullahoma, Tenn., vacuum chamber facilities are progressing "better than expected," Mathews said. However, the major hurdle, which he described as the full-scale engine start program in the chambers, would not begin for several more weeks.

Manned Spacecraft Center has accepted three modified *Agena* engines for altitude tests at Tullahoma, for sea-level tests to be conducted by Bell Aerosystem Div., and for installation in the *Agena* 5003 flight article scheduled for delivery to Cape Kennedy this week. ■

Surveyor Retro Engine Arrives at Cape



Main braking rocket engine for the first Surveyor lunar landing has arrived at Cape Kennedy from Thiokol Chemical Corp.'s Elkton, Md., plant. The solid-propellant retro-rocket was accepted for delivery by officials of Hughes Aircraft Co. and Jet Propulsion Laboratory. Hughes is prime contractor to JPL.

Checkout Requirements Push Apollo Flight into February

THE FIRST LAUNCH of the *Apollo* spacecraft has now slipped to the middle or latter part of February, NASA officials report.

The delay of the flight—originally scheduled for late last year—is attributed to the many checkout and tests required before a new spacecraft is committed to its first space mission.

Preparation and checkout of the new launch facilities for its *Saturn IB* booster at Cape Kennedy have also added to NASA's scheduling woes.

The space agency's planning schedule—which is admittedly optimistic—originally called for five or six *Apollo* flights this year, but this may have to be revised because of the delay in the first flight.

The mission—The first *Apollo* flight is designed to test the spacecraft subsystems and its re-entry heat shield. It will be a ballistic shot from Cape Kennedy into the South Atlantic, where the spacecraft will be recovered. To validate the re-entry heat shield, the Service Module propulsion system will be fired to achieve a re-entry speed of 29,000 fps.

As soon as the spacecraft impacts, inflatable spheres will be used to automatically hold it upright in the water.

The spheres, developed by the Goodyear Aerospace Corp. of Akron, Ohio, are made of polyurethane-coated fabric. Each is 43 in. in diameter and has a volume of 24 cu. ft.

In the two-man *Gemini* spaceflight series, Navy paramedics must fasten an inflatable flotation collar around the spacecraft to stabilize it in the sea.

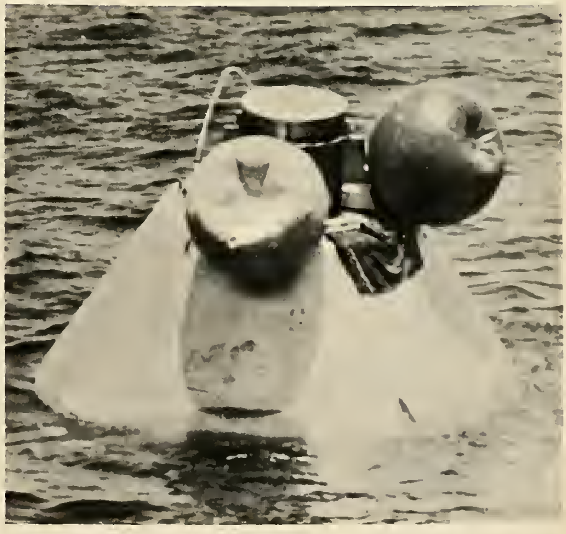
The spheres were developed by Goodyear under a contract with North American Aviation's Space & Information Systems Div., prime contractor for the *Apollo* spacecraft's Command and Service Modules.

Later flights—The second flight NASA plans in the *Apollo* program will also be a ballistic lob shot, but the spacecraft will reach a peak altitude of 650 miles in order to get an almost circular re-entry. Splashdown is to be near Wake Island in the Pacific Ocean.

SA-203, the third flight, will be used to check any venting problems in the launch vehicle's S-IVB third stage, which is powered by the liquid oxygen and liquid hydrogen J-2 engine. It will also be used to study the orbital interface between the third stage and the spacecraft.

SA-204 is planned as another unmanned orbital flight. The first manned orbital flight in the three-man series will be *SA-205*. *SA-206*, which will probably not be launched until early next year, will mark the first flight of the Lunar Excursion Module. It will be unmanned. ■

Top left: Apollo spacecraft after splashdown. Center left: Flotation bags begin to fill, tilting spacecraft. Left: Spacecraft nears upright position and is floating upright in photo at right. Goodyear Aerospace Corp. is producing flotation bags under contract to North American Aviation's Space & Information Systems Division.



Deep Submergence Project Is Upgraded

Navy makes program a separate entity and prepares to increase staff assigned to it; doctors detail findings from Sealab II

by Heather M. David

THE NAVY IS UPGRADING the Deep Submergence Systems Project (DSSP) by moving it from the Special Projects Office to be a separate project under the Chief of Naval Material.

Under Secretary of the Navy Robert H. B. Baldwin says the DSSP as a separate project will receive the intensified management and focus it now requires.

Dr. John P. Craven, presently Chief Scientist for Special Projects, will be acting manager until a senior Engineering Duty officer is assigned in June. Craven told M/R that the 15 personnel now working with DSSP in Special Projects Office will be joined by 10 additional experts from the Bureau of Ships, and an additional 15 staff members will be recruited to fill out the office.

The objective of the office will remain the same—to develop a deep submarine rescue and salvage system over a five-year period. This also includes extension of man's ability to perform useful work in the sea at a depth of 600 ft., and development of the nuclear-powered deep diving research vehicle.

Craven also disclosed that three responses to the recent request for proposals for development of the rescue vehicle have been received by his office and are now being evaluated. Responders were Lockheed, General Dynamics/Electric Boat, and North American Aviation.

All three proposals were presented "exceedingly well," Craven said, and the choice will be difficult. However, he said he hoped to have the evaluation completed in February.

The announcement of the shift was made by Baldwin last week in a speech opening a symposium in Washington, D.C., on "Man's Extension Into the Sea." Baldwin also revealed that Dr. Robert Morse, Assistant Secretary of the Navy for R&D, will now act as focal point for department-wide policy supervision of ocean engineering, and will also become chairman of a new Navy Oceanographic Policy and Programs Board.

Cautioned against speed—Considerable laboratory work was urged by Capt. Walter Mazzone, of the Submarine Medical Center, in the light of physiological results from Sealab II. He also urged caution in the extrapolation of results at one depth to another deeper depth.

In general terms, Mazzone said that no untoward results were suffered by the men in Sealab II. However, instead of extrapolation to yet greater depths, he urged actual laboratory experiments. Sealab III is now planned for early 1967, and will be placed at 400 ft.

Breathing tests were made almost daily on all members of the second team, and the results compared with control measurements of the same subjects at the surface. Seven out of 10 of the men had decreased tidal volume, and the average for all was 9% less than the control values on the surface.

Mazzone said if this is an indication of a decreased respiratory minute volume, its significance may be linked with the measurements of increased carbon dioxide in the Sealab II.

Vital capacity, the maximum amount the man can take into his lungs, was decreased by an average of 14% on the bottom. This was most depressed during the mid-portion of the bottom time, and some return to normal was found during the second week. Other changes, including a 46% decrease in maximum expiratory flow, were in line with the differences of operation in the environment, which was near seven atmospheres absolute.

An experiment in taking an electrocardiogram by sonar on a diving subject yielded some good results, Mazzone reported, and should lead to future experiments.

No trend was found in pulse rates. Temperatures, which were taken orally daily, were found to have risen above normal level after the second day. The mean was 99.8°F, 1.2° above normal.

Mazzone questioned whether this could be caused by the effects of helium conductivity—the body might be overcompensating for the fact that heat is carried away faster in the high-helium-content atmosphere.

Future—Mazzone indicated that experiments with bounce dives—going from one depth to another and back without decompression—seem to prove feasible, judging from results of work with animals and humans. In the future, it may be possible to have men stationed at a depth of 600 ft., making excursion dives to depths of 1,000 or 1,500 ft. without decompression. ■

Hughes Building New 'Hybrid' Falcon

U.S. AIR FORCE

Original falcon spreads wings atop AIM-4D, latest air-to-air Falcon missile being developed for U.S. Air Force by Hughes Aircraft Co. Infrared-guided weapon is cross between existing GAR-2A and GAR-4A versions of Falcon, and will be used by both the Air Defense Command and the Tactical Air Command. Hughes expects contracts involved to exceed $70 million.

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R&D Needs Outlined; NAA Transportation Study To Go On

NORTH AMERICAN AVIATION is expecting a follow-on contract from the state of California as a result of its study on the application of systems analysis techniques to transportation problems.

This was revealed following a session of the House government operations research and technology subcommittee Jan. 10.

Jack J. Jones, director of transportation studies at North American, indicated that the contract would involve a computerized engineering model of the earlier study, completed last September. The firm is also conducting talks with the Secretariat of the United Nations and three foreign countries on the application of systems analysis to various problems, company officials said.

Witnesses at the three-day session questioning the decision-making process in federal research and development efforts generally agreed that in the fields considered—transportation, pollution, and housing—government leadership and funding for systems approach techniques would be highly beneficial.

However, a need for specific proposals in these social and economic areas was stressed by Presidential Science Advisor Donald F. Hornig. "We cannot buy and create progress in a field which is not ready to progress," Hornig told the subcommittee.

In order to proceed, ideas on how to satisfy needs at reasonable cost must be identified and developed, and talented people must become interested in these tasks, he said.

Witnesses stressed the need for federal funds at the development or demonstration phase in most instances. In the area of water pollution control, for instance, it was pointed out that communities cannot afford the cost or risk of building experimental demonstration plants themselves.

Dr. Leon W. Weinberger, chief of the basic and applied sciences program of the Federal Water Pollution Control Administration of the Department of Health, Education and Welfare, indicated that there would be a need for $200 million in federal research funds for effort on this subject during the next 10 years.

Weinberger pointed out that while about 20 proposals for handling systems should come up each year, only three or four of these could be considered for engineering development. Construction of demonstration systems, he indicated, would cost about $9 to $10 million apiece.

Transportation—The necessity of federal outlay to initiate progress on urban transportation problems was stressed by the Rand Corp.'s Richard R. Nelson.

Nelson pointed out that in cases in which very specialized inputs are required or when considerable R&D is required to meld components and materials together in an efficient, new system, "private suppliers are naturally reluctant to invest in an expensive and uncertain project which, if successful, will have only a single and often capricious potential buyer."

Among the interesting concepts North American has studied, Jones said, is a tube train which could travel in the 300- to 500-mph range, comparable with jet aircraft for speed, but avoiding dependence on weather. The tube through which the train would travel, either above or below the surface, would guard against the possibility of obstructions and muffle sounds.

One type of tube train, Jones said, is the gravity vacuum train, which uses the pendulum principle. Beginning with each station, the tunnel would be laid out following a pendulum path. The train would gather momentum from gravity and from a combination of the vacuum ahead of it and the ambient air behind it, Jones said. The vehicle would build up speeds to 500 miles per hour, then reverse the process as it came up to the next station.

Housing—In the field of construction, however, witnesses made it clear that while systems analysis techniques should be applied, aerospace firms are not necessarily the ones to do it.

A "significant number of attempts" have been made by aerospace companies to diffuse building industry skills and organizational patterns into their structure, Ezra D. Ehrenkrantz of the University of California's Dept. of Architecture told the subcommittee. However, he said, this has not been of much help to date. "It would probably be as difficult for Johns-Manville to build an airplane as it would for Northrop Aviation to build schools," he said. ■

Variable Sweep Wings: A report from General Dynamics

A major step forward in aircraft design:

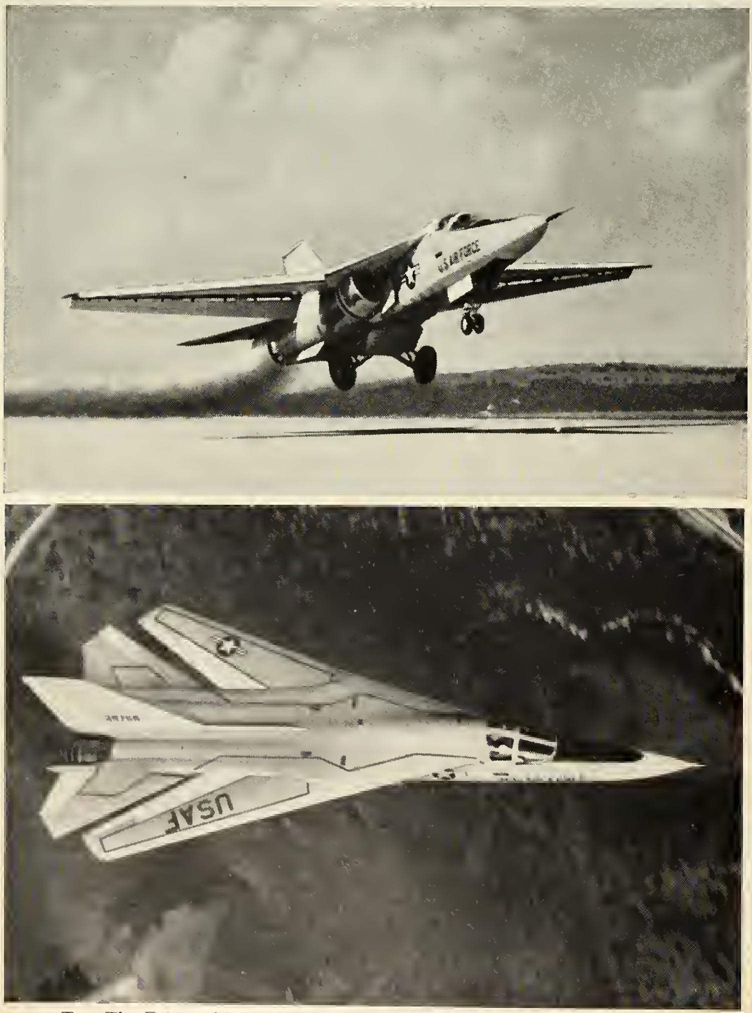
This week, several pilots redesigned their airplanes in flight. Shortly after takeoff, each pilot moved a trombone-shaped slide in his cockpit and folded back the wings of his plane.

The ability to do this made the F-111's they were flying the first aircraft that can (1) operate from short landing fields, *and* (2) fly economically for long subsonic cruise ranges or ferry itself across an ocean, *and* (3) strike supersonically at treetop height *or* dash at two-and-a-half times the speed of sound at an altitude of 12 miles.

The key is its variable sweep wing. Today the first eight developmental F-111's, built by General Dynamics, are daily demonstrating the feasibility of a movable wing—a development that finally makes a truly multipurpose airplane practical.

The matter of flight envelope:

Every aircraft has a specific "envelope" —a set of limitations, or boundaries, of speed and altitude, within which it can operate effectively. The final design of a plane depends upon which of several possible purposes is most important.



Top: The F-111 with its wings extended straight out for high lift at takeoff.
Bottom: Wings being swept back to allow F-111 to reach supersonic speeds.

A long wing extended straight out is best for short takeoff and landing, long range and endurance, or high load-carrying characteristics. For the high lift demanded, a large amount of wing surface is needed.

But as speed increases, less lift is needed from the wings. In fact, at high speeds, large wings increase resistance from the air. Such an airplane can be pushed to supersonic speed by brute power, but not efficiently.

This resistance is commonly called drag, and one way to reduce it has been to sweep the wing back. For instance, the modern passenger jet, whose wings are partially swept back, can fly efficiently for long distances just below the speed of sound. But the swept wing provides less lift, and such aircraft need long runways, sometimes up to two miles long, and special braking devices.

Very high speeds—faster than sound —can best be reached with a very small wing, sometimes in a triangle or delta shape. But the still lower lift can require even longer runways, and additional braking devices such as drogue parachutes. The very small wing offers considerably less fuel efficiency for long-range, subsonic flight.

Three aircraft in one:

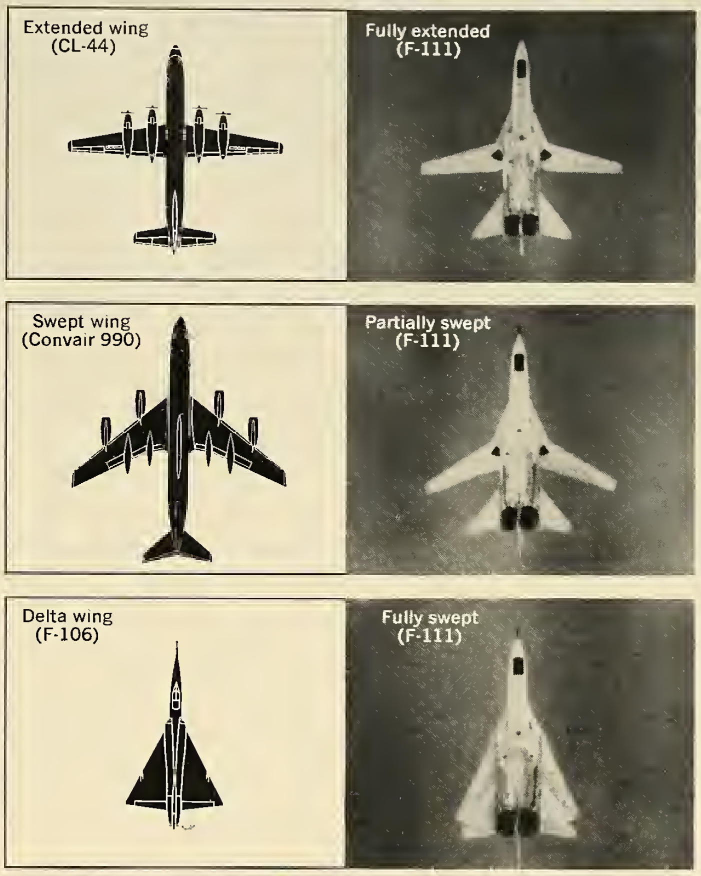
A wing whose position can be changed by a pilot *in flight* gives a single airplane the special talents of all three types. With the wing fully extended, the aircraft has high lift for short takeoff or landing or high-load capacity. With the wings partially swept, efficient long-range subsonic flight becomes practical. Pulling the wings all the way back to their smallest exposed area provides supersonic dash, without having sacrificed either high lift or cruise economy.

Previous—and impractical—attempts to achieve variable wing geometry go all the way back to 1911. The chief problem: an undesirable relationship between center of gravity and center of lift as the wings moved would cause an airplane to nose up and down sharply—become longitudinally unstable.

How it operates:

Not until 1960 did the National Aeronautics and Space Administration conceive the answer to this instability—simultaneously sweeping both wings around separate pivot points which were moved out on the wing root rather

How wing configuration determines flight envelope



Left, top to bottom: Drawings of planes flying today. Extended wing of transport provides relatively short takeoff and landing with heavy loads. Swept wing of passenger liner provides less lift, but allows the plane to fly efficiently just below the speed of sound. Small delta wing of military fighter reduces air resistance (drag) and allows the plane to fly at supersonic speeds.

Right, top to bottom: Photos of the F-111 show how the variable sweep wing gives it the advantages of the extended wing, swept wing and delta wing—all in one plane.

than having a single pivot in the center of the fuselage. The concept has been refined and developed by General Dynamics through more than 22,000 hours of wind tunnel testing, and more than 25 million man-hours of design and development.

The F-111's variable wing can be moved in flight from its fully extended position (technically with 16° of sweep measured at the leading edge) to a full sweep of 72.5°, with the wings tucked back against (and much of them actually inside) the fuselage for a narrow delta shape. The position of the wings can be set and held at any position between these two extremes, with the pilot himself deciding what wing setting is best for maximum performance in a given set of circumstances. He can normally lever the wings from one extreme to the other in about twenty seconds.

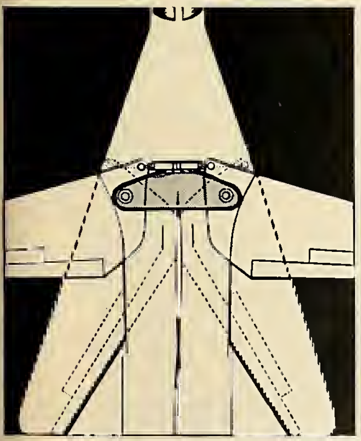
The precision of design is so exact and the wing so balanced that negligible elevator trim is needed to compensate for full sweep of the wing.

Heart of the system:

The heart of the F-111's variable sweep system is a 14-foot steel yoke across the fuselage (see drawing below).

The movable portions of each wing are fastened to the yoke by 8½-inch diameter high-strength steel pivot pins. Forward of the yoke hydraulically powered actuators, responding to the pilot's control selection, move the wings from one position to another.

For additional high lift at takeoff and landing, full span slats and flaps are incorporated into the wing. The wing itself is ingeniously tapered so that much of its area when fully extended is highly cambered—that is, with a relatively thick curve for greater lift—and thin at the area remaining exposed when wings are swept back for high-speed flight.



How the wing works. A 14-foot steel yoke, with its 8½-inch diameter pins, on which the wings pivot, is the heart of the variable sweep winged F-111. The yoke and pins support the whole plane in flight. A jackscrew just forward of the yoke actuates the wings during sweep.

The future for the sweep wing:

Since the Wright Brothers' first breakthrough in the art of manned flight, there have been relatively few major advances in the basic art of airplane building. One was the introduction of light aluminum structures, another the introduction of the turbine—better known as the jet—engine for propulsion.

The variable sweep wing represents a similar major step forward. For any category of aircraft—military, commercial or private—where the combination of very high-speed flight, long economic cruise and high lift for easy takeoff and landing is desired, the variable sweep wing sets the new standard. Even space ships may ultimately incorporate some form of variable geometric wing to make them more maneuverable within different atmospheres.

General Dynamics is a company of scientists, engineers and skilled workers whose interests cover every major field of technology, and who produce for defense and industry: aircraft; marine, space and missile systems; tactical support equipment; nuclear, electronic and communication systems; and machinery, minerals and gases.

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Aircraft ground support unit A/M32A-60 uses AiResearch gas turbine to produce AC and DC power and compressed air. Units were designed and produced by Wolverine Diesel, additional units produced by Libby Welding.

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Technical Countdown

ELECTRONICS

Sun-Pumped Laser Carries TV

Capability of a Sun-pumped laser to carry television modulation has been demonstrated in the laboratory by RCA's applied research organization. A 31-in. parabolic mirror concentrated a 400-watt solar input onto a water-cooled "YAG" crystal (double-doped yttrium aluminum garnet). The half-watt continuous laser output was modulated by a gallium arsenide electro-optic crystal that rotated the beam's plane of polarization in proportion to the modulating signal. Next test of the device, built for NASA's Manned Spacecraft Center, is to be a six-mile transmission from the Camden laboratories to RCA's Cherry Hill, N.J., facility. The 31-in. mirror is mounted on an equatorial Sun-tracking mount.

Pattern Recognition Computer Progresses

Fabrication of the ILLIAC III pattern-recognition computer is reported to be well under way at the University of Illinois. Uniqueness of its design is in a parallel organization that enables it to carry out 1,024 logical operations at once. Potential uses run from processing of bubble chamber photographs, which is why AEC is spending $2 million on it, to the processing of electron and optical microscope images, library automation, and photographic and map analysis. ARPA is spending $620,700 in Fiscal 1966 for support of remote consoles, a 65,536-word core memory and a disc backup store. These additions will allow users with only occasional data-processing demands to have access to the central pattern-recognition computer from several remote consoles on and off the Illinois campus.

Underwater Acoustic Lens Being Developed

A collapsible sphere for focusing sonar beams at depths of 2½ miles is being developed by North American Aviation's Columbus Div. Built up of a series of air-filled flexible tubes, the new underwater acoustic lens makes use of the Luneberg lens principle. A hydrophone placed on the surface of the sphere will receive signals originating from a single direction in space. Alternatively, the lens can be used to produce a directional beam from a sound generator. Developed by the division's ASW Marine Systems group under contract from the Office of Naval Research, the lens prototype has been tested at the Naval Research Laboratory's Lake Seneca, N.Y., facility. Deep sea tests are scheduled for April in the Atlantic.

Laser Measures Gas Density

Use of a laser beam to measure gas density has been reported by scientists at Cornell Aeronautical Laboratory. Uses include measurement of gas densities in boundary layers, hypersonic wakes, and rocket base heating flows in ground-test facilities. The technique is applicable in situations where a physical probe can produce undesirable distortion of flow. Main disadvantage is the scattering produced by gas contaminants. However, the Cornell experiments were carried out in vacuum chambers where measurements of dry filtered air were required. A free-running O-axis ruby laser was fired through a thick transparent plastic window and a series of apertures. Principle behind the density probe is that the energy scattered out of the beam of light is proportional to the number density of scattering centers and the scattering cross section. Output of the detectors was found to be linear, with density over three orders of magnitude.

MATERIALS

Silicon Nitride Challenges SiO

Use of silicon nitride in place of silicon oxide produces field-effect transistors with greatly improved stability, reports Dr. Roger Newman, manager of solid-state sciences at Sperry Rand Research Center. The technique is also said to improve the characteristics of diodes and integrated circuits. First production devices are expected within a year. The nitride is laid down as a deposition process, in contrast with the technique of growing silicon oxide up from the wafer. As a result, the nitride film can be grown at 10 times the speed of the oxide and at much lower temperatures. Thickness can be varied from Angstroms to mils. Tests on field effect devices show that the operating point of the gate is not displaced by biasing it for a few hours at 100° C. In contrast, reports Newman, MOS devices can have their operating point displaced by more than 70 volts by such treatment.

Elastomeric Seals Movable Submerged Nozzle

Reduced weight and improved reliability are achieved by using an elastomeric seal around a movable submerged nozzle instead of a rigid structure with sliding seals. Developed by Lockheed Propulsion Co., this "Lockseal" system has been demonstrated during a two-minute firing of a 36-in.-dia. test motor containing 2,000 lbs. of solid propellant. The nozzle was rotated repeatedly through 360 degrees to demonstrate omnidirectional thrust vectoring. Lockseal, developed under contract from the research and technology division, Rocket Propulsion Laboratory, Air Force Systems Command, is expected to replace complex and expensive components used in present gimballed nozzle systems. The seal carries nozzle deflection loads and permits flexible movement of the nozzle through any axis by hydraulic actuators. A flexible insulating barrier protects the seal from heat and erosion during firing.

PROPULSION

Univ. of Utah to Study Solid Combustion

The chemical processes in the combusion of solid rocket motors will be studied by the University of Utah under a one-year, $67,135 contract from NASA's Office of Advanced Research and Technology. The investigation will use newly developed fast-scanning spectroscopic instruments. The project will involve the gas phase near the reacting surfaces in four different experiments, with emphasis on high-flux decomposition, chemical arc, flame extinguishment and non-acoustic instability. The chemical arc process will provide information on the interaction of the ammonium perchlorate oxidizer and the polymer fuel. The reaction region is ordinarily very narrow. In the arc method, chemists can make the combustion flame stand far enough away from the surfaces so that the reactions are spread over a wider region and may be more easily observed spectroscopically.

oceanology

Commerce Bids for Sea Research Role

Department sets up Institute of Oceanography in advance of Congressional legislation; first task is to 'describe' ocean

by William S. Beller

IN THE FACE of Congressional uncertainty as to who should manage the nation's overall oceanography program, the Dept. of Commerce, with little fanfare, has set up its own Institute of Oceanography.

Commerce's move, made several weeks ago, is part of the Department's plan to consolidate its interests in environmental sciences into the Environmental Science Services Administration (ESSA). ESSA itself was created last summer and brought together the environmental science service activities of the Weather Bureau, Coast and Geodetic Survey and the Central Radio Propagation Laboratory of the National Bureau of Standards.

At that time, Congress had two oceanography bills on its hands—the Magnuson bill which passed the Senate at the last session and a House-passed bill sponsored by the Merchant Marine and Fisheries Committee. A spokesman for the Merchant Marine Committee told MISSILES AND ROCKETS it hopes a conference will be called early in this session to arrive at a compromise bill.

Thus, in the national scheme, the status of Commerce's Institute of Oceanography is uncertain except that it has put in its bid as the research arm of any oceanographic instrumentality Congress finally sets up. At the very least, the institute will carry on Commerce's programs.

The Institute of Oceanography, headed by Dr. Harris B. Stewart, Jr., is one of four ESSA institutes: Telecommunication Sciences & Aeronomy; Earth Sciences; and Atmospheric Sciences. In addition to these institutes, ESSA includes the Weather Bureau, Environmental Data Service, Coast and Geodetic Survey, and National Environmental Satellite Center.

In order to understand the Earth's environment, ESSA Administrator Robert M. White says his agency will use a "remarkable array of ships, aircraft, satellites, computers and other scientific facilities. . . ."

The systems approach that marked the formation of ESSA was reflected by White describing the oceanographic institute: "Lack of knowledge about the interactions between the atmosphere and the ocean is a major obstacle to long-range weather forecasting and to improving predictions of ocean waves, water temperatures, coastal currents, and surf and other ocean conditions."

As an illustration, White noted that "the atmosphere affects the ocean as much as the ocean affects the atmosphere." The Institute of Oceanography is taking its text from this remark.

The institute expects a budget of several million dollars for Fiscal 1967. This is for salaries, facilities, equipment and outside contract work and will finance the organizational phase.

The institute's research work is directed by 15 senior scientists, assigned to one of five laboratories—Physical Oceanography, Marine Geology & Geophysics, Sea-Air Interaction, Land-Sea Interaction (Norfolk, Va.), and Pacific Oceanographic (Seattle, Wash.), The first three laboratories are at ESSA headquarters, Rockville, Md.

Character of the sea—The first of four major institute jobs cited by Stewart is "to describe the state of the ocean." Once the equation of the seas is found, it will be used to help forecast weather and ocean environment. The equation, of course, will be far more pictorial than symbolic. It will involve vast amounts of data from ocean surveys.

One of these surveys is already shedding new light on the Gulf Stream, one of the ocean's mysterious "rivers." This year-long study—the most extensive of the Gulf Stream since Benjamin Franklin suggested quickening coastal commerce by appropriately routing vessels into the stream—started six months ago with the departure of two oceanographic vessels from Norfolk, Va., and Savannah, Ga.

One of the jobs of the vessels is to find out the strength of the constantly changing stream. It is described as having a flow 22 times as great as all the rivers of the world.

Preliminary findings, disclosed a few days ago by ESSA, show that:

Sea smoke photographed 23 miles off Cape Kennedy illustrates sea-air interaction and a striking weather phenomenon.

—The Gulf Stream expands and contracts like a living thing but in a seemingly irregular fashion;

—The stream's course also varies, at times 15 to 20 miles a day and up to 250 miles during the first few months of the study;

—Part of the stream breaks off from time to time, forming eddies. One was found this past September lying south of the stream, rotating counterclockwise at about a third of a revolution a day. It was about 60 mi. in diameter;

—The stream may extend to the bottom of the sea, even after it leaves the relatively shallow water (about 2,400 feet) over the Blake Plateau and proceeds northeastward over the deep sea. The Blake Plateau is a flat underwater shelf off the South Carolina coast.

On the basis of bottom current measurements, one oceanographer theorizes that the stream has a champagne-glass shape (minus the bottom) as it leaves the Blake Plateau.

Another program aimed at supplying terms in the general equation is SEAMAP (Scientific Exploration and Mapping Program). The original program was recommended by the National Academy of Sciences, affirmed by the Interagency Committee on Oceanography (ICO), and carried out by the Coast and Geodetic Survey since 1961.

SEAMAP is part of this nation's quest for a systematic mapping of the oceans. Up to now, the work has been limited to the area between the Aleution and Hawaiian Islands. However, two new oceanographic vessels, scheduled for commissioning this year and assigned to the institute, will be used to expand the survey program.

These two ships—the Oceanographer and the Discoverer—are said to be the largest, most modern oceanographic research vessels built in the United States. Each ship will have more than 4,100 sq. ft. of laboratory area.

Devising an oracle—End products of the institute are the mechanisms for predicting oceanographic and possibly atmospheric disturbances. One of the first sought is for tidal predictions. Scientists have at hand a mass of uncoordinated tidal data stretching back many years. This information will be furnished to computers which will search for meaningful patterns.

Tsunamic or seismic sea waves wreak more havoc on the mainland than any other ocean convulsion. These waves—often mistakenly called tidal waves—usually stem from earthquakes occurring beneath the ocean or along coastlines. The 1964 Good Friday earthquake in Alaska produced the most recent major tsunami. It was observed and reported over the entire north Pacific Ocean and much of the south Pacific, causing millions of dollars in damage along the Alaska, California, Oregon and Hawaii coasts.

An April 1, 1954, earthquake in the Aleutian Islands generated a tsunami that crashed 55-ft.-high waves on the shores of Hawaii and other seacoasts.

"Now we have a system that predicts very well tsunami arrival times," said Stewart, "but we are at present unable to predict the height the waves will reach at any given place." Therefore, the institute is undertaking a joint program with University of Hawaii to develop a prediction method. Stewart called the problem "one of the worst, but we have outstanding men on it."

Typically, a tsunamic wave travels 450 to 500 miles an hour across the ocean, has a free wavelength as long as hundreds of miles, but an amplitude of only several feet. Thus, it can carry a tremendous amount of momentum but remain undetected by ships at sea or aircraft. "The problem's a real stinker," repeated Stewart.

Although the institute will not do any weather forecasting, it will do extensive research into the interaction between the sea and the atmosphere. Meteorological observations are now taken mostly from posts on land masses, particularly in the northern hemisphere. "Yet 80% of the Sun's heat coming to Earth hits the oceans, which act as the flywheel that keeps the atmospheric circulation going," said Stewart.

To help with the interface problem, the oceanographic ship Pierce, belonging to the Coast and Geodetic Survey and working on the Gulf Stream studies, has a meteorologist aboard. He uses a new "wing" device to make boundary layer measurements up to a height of 1,000 ft. above the ocean's surface. Moreover, the institute is now developing an anemometer able to measure wind speeds along a vertical profile through the boundary layer. The institute is also sponsoring studies aimed at developing interface equations.

The institute could engage in many prediction projects but a large number would probably not hold sufficient economic payoffs. There's no point in looking into ocean surface swells up and down the California coast if the only foreseeable beneficiaries would be San Diego lobstermen, for example. "We must have a good economic requirement to do the work," Stewart stressed. Of studies not underway, but apparently needed, he named:

—Sea-surface temperature distributions;

—Variations in coastal and offshore currents, chiefly prediction methods;

—Sea state, that is, wave heights;

—Surface conditions on a wide scale, particularly predictions;

—Changes in bottom conditions and coastlines—for example, erosion of harbors and beaches.

Data analysis—"We want to be sure that with the increased number of ships and buoys we will have, we don't become completely snowed with data," said Stewart. "Right now we are working to get the best techniques for automatic processing of tidal data, sounding data from ships and various types of geophysical data." These data include gravity, magnetic, and seismic profiling.

Buoy development—In the face of grandiose schemes to network the oceans with vast arrays of buoys, the institute wants to start such networking on a pilot scale involving three to five buoys at most. Stewart concedes it is not economical to send men and ships out to collect a mass of oceanographic data. And the cost skyrockets for collecting time-dependent data such as wind, barometric pressure, air temperature, salinity, and current and so on. "The logical thing to do is send a buoy to do a man's job," affirms Stewart.

This summer the institute plans to emplace a small number of buoys off the continental shelf of the east coast to get a feel for the range of the ocean's variables. Information from this work is expected to point out favorable paths for buoy development. At the same time, the buoys will probably test out systems able to make both meteorological and oceanographic measurements.

Where inland waters and harbors meet the sea, man experiences the most concentrated effects of the ocean. Here water pollution and land erosion are clearly seen, and their effects on recreation and fishing poignantly felt. "It would be good to be able to predict flushing times of harbors," said Stewart, indicating that this ability might keep the damage from spreading. ■

OAR To Use Own Vehicles for OV Shots

Low batting average in program to date underscores risk of launching satellites as secondary payloads; eleven launchings planned for 1966

by Rex Pay

El Segundo, Calif.—When *Titan III-C* failed to insert *Orbiting Vehicle 2-3* into orbit it lowered the Air Force Office of Aerospace Research ratio of successful orbital missions from one in four to one in five in 1965—and drove home the fact that it is risky to launch satellites as secondary payloads on booster development flights.

This year the situation is expected to change. OAR will make greater use of its own satellite launchers starting with the twin *OV1* satellite launch scheduled for Jan. 20.

Five types of *Orbiting Vehicles* are used in the Aerospace Research Satellite Program, which provides Air Force laboratories with a low-cost means of carrying instruments into space. In 1965, ARSP supported launching of 139 sounding rockets, seven space probes carried by *Scouts* and *Atlas* ICBM's, and five satellites. In 1966, 11 satellites are planned. Total OAR budget is about $10 million per year.

Special case—The low budget of the *Orbiting Vehicle* program gives it a number of distinctive features from the experimenters' point of view. Commenting on the failure of *OV2-3*, Lt. Col. John C. Hill, who commands the Los Angeles OAR unit implementing the *OV* program, said: "This is an illustration of what happens when you try to save money and go high risk—scientists lose a year of work." In most cases this occurs where experiments and associated equipment are developed for a special orbit, which is then not achieved.

In fact, *Orbiting Vehicles* tend to have rather unusual orbits. *OV2-3* was scheduled for a circular 18,200-mi. orbit, very high for a 427-lb. satellite of its sophistication. It carried 15 separate experiments, mainly for solar studies, and, had it succeeded, would have been a very valuable secondary payload.

However, the unusual orbit often results from unique primary mission requirements. Previous to *OV2-3, OV2-1* was carried on a *Titan III-C* development flight that called for a 400-mi.-perigee, 4,000-mi.-apogee orbit. When missions such as these fail, there is no back-up spacecraft, because a repeat attempt at the same orbit is unlikely. Hence, an appreciable amount of scientific effort is lost.

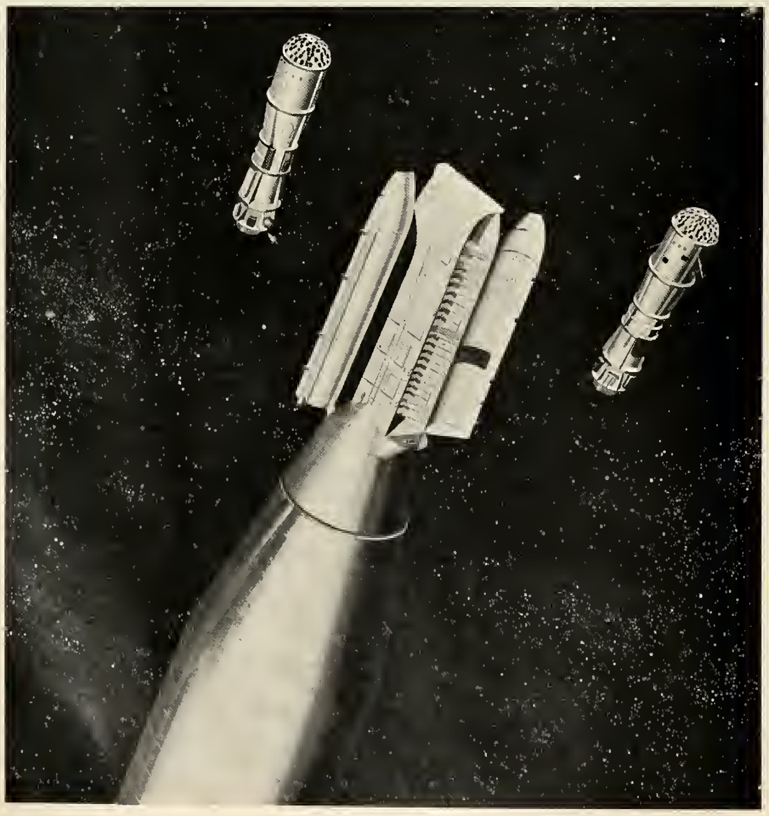
OV1-2, the successful OAR satellite, was a primary payload on an OAR booster. It has the distinction of moving in a retrograde orbit of 145 degrees inclination, due to WTR launch restrictions.

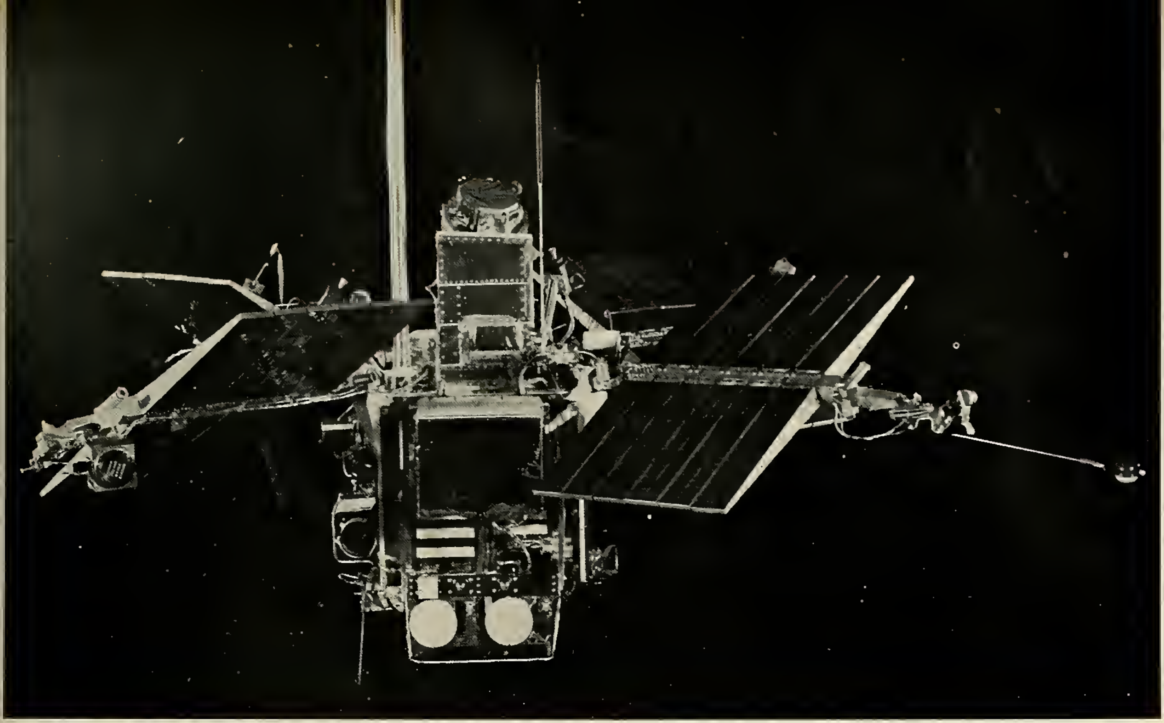
Growing program—ARSP, now about five years old, provides orbiting vehicles to carry instruments for other military laboratories and NASA, as well as Air Force laboratories. Rides are also provided on other space vehicles such as the AF Space Systems Division's *Agena-D* or the *MOL Gemini* Heat Shield Qualification Test.

For Fiscal Year 1966, OAR has selected 22 experiments for satellite flights. For the following year, 30 experiments have been selected. Experiment complexity can vary from a small black box to a complete spacecraft.

Experiments for ARSP satellites are proposed by laboratories as valid parts of their current research programs. A

Twin OV1 research satellites pop from protective pods to go into separate orbits in artist's drawing of planned climax of Jan. 20 mission. GD/Convair built satellites.





OV2-3 Sun-oriented satellite built by Northrop Space Laboratories, is shown at Cape Kennedy prior to launch on Dec. 21 that failed to put it into proper orbit.

laboratory supports the fabrication and test of experimental hardware and also the subsequent data analysis. An OAR Phase I Payload Review meeting then draws up a priority list for the proposed experiments, based on scientific or engineering merit, scientific method and feasibility. There are 200 proposed experiments, including sounding rockets, on the current priority list.

A second review, Phase II, inserts managerial modifications into the priority list and establishes monetary cutoff points for various possible ARSP funding levels.

Further checks by AF Headquarters and Dept. of Defense follow, and NASA is consulted to discover whether any duplication of research is likely.

When the funding level has been agreed on, the implementation of the resulting program is chiefly the concern of the Los Angeles office of OAR, commanded by Hill and located at AF Space Systems Division Headquarters. It procures most of the *Orbiting Vehicles,* obtains boosters or secondary rides, integrates experiments on a spacecraft, and integrates spacecraft with boosters.

Procurement is generally carried out through SSD's procurement office. Integration of spacecraft experiments to obtain a meaningful payload is conducted with support from SSD, Research and Technology Division and OAR laboratories. Integration of the spacecraft with the booster is accomplished in cooperation with SSD and Ballistic Systems Division.

Good start—*OV1,* the first of the *Orbiting Vehicle* series, was also the first to fly successfully. It evolved out of OAR experimental pods attached to the side of *Atlas* missiles, and was developed by General Dynamics/Convair. Addition of a propulsion module and guidance system to a ballistic pod gave a vehicle that could ride piggyback on a ballistic missile to altitude, then separate and go into orbit under its own power (M/R, p. 24, June 15, 1964).

Initially, the *OV1* series was intended to fly as secondary payloads on five *Atlas ABRES* flights over the Eastern Test Range. When this program was transferred to the Western Test Range, the new westward trajectories severely limited the possibility of orbiting a useful *OV1* payload. As a result, OAR decided to purchase its own surplus *Atlas* boosters. Payload cost could be brought down by flying as many as three satellites from one booster—one on the side and two on the nose.

Ballistic pods continue to fly on *ABRES* flights.

Currently, OAR is using *Atlas D* boosters that fly out of "coffin" launchers oriented towards certain targets. This feature and range safety requirements result in retrograde orbits for the early members of the *OV1* series. Guam is a typical "aiming point" for these launches.

Designation explained—Within an orbiting vehicle series, a satellite is given a number that identifies its payload, not its place in the launching sequence. *OV1-1* was launched in January, 1965, as a side pod on an *Atlas ABRES* launch, but did not eject from its container. *OV1-3* was launched in May and was the first to fly on an OAR-owned booster. It was a side pod, the booster carrying a dummy payload in its nose to check out this new flight configuration. A booster failure destroyed the satellite.

OV1-2 was launched in October, 1965, from the nose of an *Atlas D,* where a second dummy payload counterbalanced it. The orbit achieved was 1,871 mi. apogee, 209 mi. perigee and 146 degrees inclination. The same launch vehicle carried a ballistic pod containing Naval Research Laboratory experiments.

OV1-2 contains an instrument package to investigate the protection required by man against radiation in space. The package, supplied by Northrop Space Laboratories for a program directed by the Biophysics Group of the AF Weapons Laboratory, includes tissue-equivalent material and means for mapping the Van Allen Zones.

Experiments such as these gain priority due to their relevance to the *Manned Orbiting Laboratory* design. One of the prime aims of *OV1-2* is to evaluate the ability of current computer programs to predict radiation doses inside space vehicles.

Next chapter—*OV1-4* and *OV1-5* are currently scheduled to be flown on Jan. 20th. *OV1-4* carries a zero-g biological experiment and is intended to go into a 480-mi. orbit. *OV1-5* is a gravity-gradient-stabilized satellite with optical experiments on board and is intended for a 550-mi. circular orbit. Both satellites will fly in retrograde orbits at an inclination of 145 degrees (M/R, Dec. 6, 1965).

OV1-4 will carry a 30-day Aerospace Medical Division experiment to study the effect of weightlessness and radiation on a single-cell Chlorella algae and multi-cell duckweed. Photoelectric cells will measure cell division of organisms. Also on board is a Materials Laboratory, Wright-Patterson AFB, Ohio, experiment to measure the effect of the space environment on thermal coatings.

OV1-5 will carry a 102-lb. payload developed by OAR's Cambridge Research Laboratory for study of ultraviolet, visible and infrared radiation from the Earth and atmosphere.

Summer and fall—The satellite portion of *OV1-6* will fly on the *MOL Gemini* Heat Shield Qualification Test next fall. Designated *OV1-6S*, it will carry an "optical decoy" experiment for the Avionics Lab at Wright-Patterson. IIT Research Institute will prepack balloons that will be deployed during the flight to be the subject of radiometer measurements from the satellite. At the same time, ground observations of the balloons may be made from the Air Force's ElectroOptical site at Cloudcroft, N.M.

OV1-7 and *OV1-8P* will fly next summer. *OV1-7* will carry radiation and optical experiments for the Space Physics Laboratory of Aerospace Corp. (on behalf of SSD), a cosmic radiation experiment for Cambridge Research Laboratories, a magnetospheric electric field experiment for NASA's Goddard Space Flight Center, and a Glotrac and C-Band transponder for the National Range Directorate. This last is unusual in that it is not for research but for calibration of range antennas, and hence is charged differently.

One of the Aerospace SPL experiments is a solar-pointing instrument that measures oxygen distribution and X-ray flux. The optical experiment is concerned with multicolor night glow photometry. Gravity-gradient stabilization will be used for the satellite.

OV1-8P is a canister attached to the *OV1-8* propulsion module. Built by GD/Convair, the canister will carry a 30-ft. Goodyear inflatable sphere. This is made of ablative material that will evaporate to leave a reflective grid for communications experiments. The Avionics Lab at Wright-Patterson AFB is carrying out this experiment.

OV1-9 will carry two Cambridge Research Laboratory experiments, measuring cosmic and exospheric radiation. *OV1-10* will carry experiments for SSD, CRL, ASD, and CRL to measure optical radiation, magnetic fields, thermal coatings performance, and cosmic radiation, respectively.

OAR is negotiating for more *Atlas D* boosters and asking that they have a capability for near-polar orbital inclination, to satisfy a demonstrated need for polar orbits.

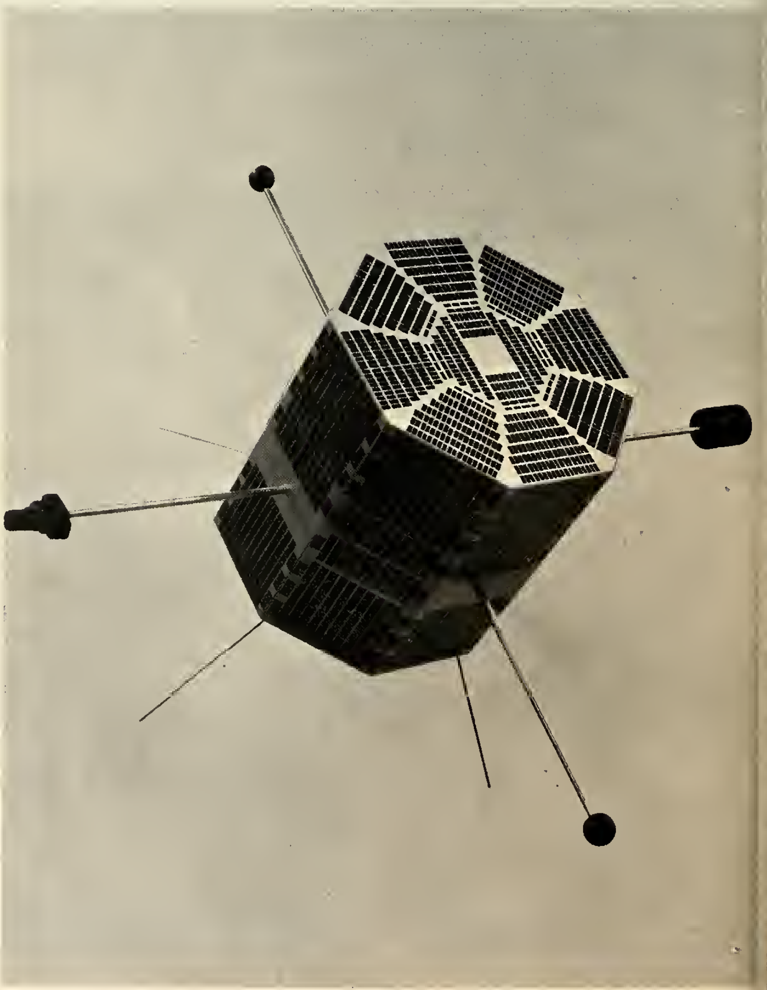
OV2 program—The *OV2* series makes use of structures that were originally intended for the *ARENTS* program. All of these are scheduled as secondary payloads on *Titan III-C* research and development missions. Both *OV2-1* and *OV2-3* failed to go into orbit because of a *Titan III-C* Transtage failure apparently caused by a malfunction in the booster's attitude control system (M/R Jan. 3, p. 14).

OV2-2 and *OV2-3* each carried 14 experiments for OAR. Both were "particle" satellites designed to provide a better understanding of the physics of space radiation and its relation to the Sun. Space Systems Division sponsored nine experiments in each vehicle, which were carried out for the most part by the Space Physics Laboratory of Aerospace Corp. Other laboratories sponsoring experiments were the Air Force Cambridge Research Laboratory (eight experiments) and the Air Force Weapons Laboratory (two experiments).

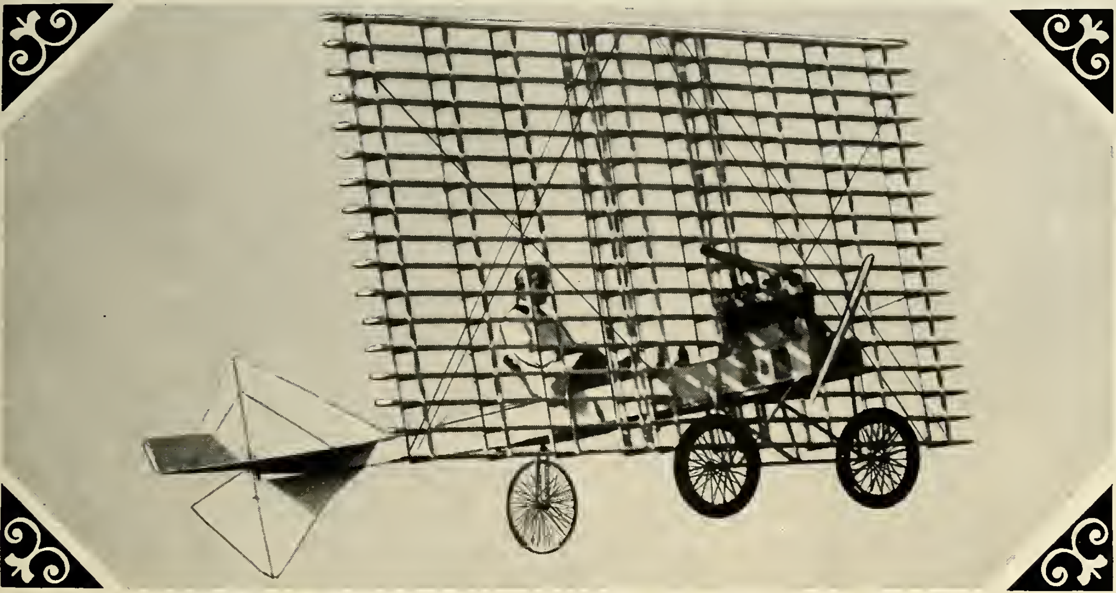
One of the objectives of these satellites was to gain an understanding of the mechanisms whereby particles enter and leave the trapped radiation belts—to enable prediction of nuclear weapons effects in the atmosphere.

Two satellites in this series reached only the tentative planning stage before the cancellation of the *Titan III-C* missions for which they were intended. Originally, three 250-mi. circular-orbit missions were scheduled for *Titan III-C*. These were ideal for optical measurements, and *OV2-2* was planned for this assignment. An Earth-escape or lunar mission was also scheduled for *Titan III-*

First launch of OV3 family, being built by Space-General, is slated for spring from Western Test Range. Two more WTR flights will be followed by one from Wallops Island.



THOSE MAGNIFICENT MEN IN THEIR FLYING MACHINES



"Phillips Multiplane" From the 20th Century-Fox motion picture "Those Magnificent Men in their Flying Machines"

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A flying blind of the Venetian category was the Phillips Multiplane designed by Horatio Phillips in 1907 in his search for a workable flying machine. It didn't work too well. Due to longitudinal instability, only short hops were made. Phillips will always be remembered for his work on wing sections which were evolved with a "dipping front edge" or "Phillips' entry."

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(Continued from previous page)

Structures Engineers—Structures Engineers to participate in the design, & conduct the necessary structural analysis to substantiate the design of Aerospace vehicles & ground support equipment. A working knowledge of the basic methods of stress analysis including the fields of plates & shells, redundant structures & fatigue strength analysis is desired. B.S. or M.S. in AE, CE, ME, or applied mechanics or equivalent is required. Both Senior & junior level positions available. AEROSPACE EXP. IS DESIRABLE, BUT NOT MANDATORY.

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Stabilization & Control Engineers—B.S. in E.E. or Physics, with 3 to 5 years experience in aircraft or missile electronic system testing (specifically digital programmer electronics). Primarily assignments will involve integrating & testing of the LEM mission programmer including the establishment of requirements for integration test procedures, conducting tests; evaluation of test results & the writing of final test summaries & reports.

Automatic Checkout Engineers—B.S. E.E. with a minimum of 2 years experience in the development of, or application of, automatic checkout equipment. Work will consist of application of ACE to the checkout of major electronic systems on the LEM, such as radar, navigation—guidance, power, communications, stabilization & control.

Systems Flight Test Engineers—BSEE with 5-10 years experience in aircraft with missile electronic system testing with specific experience in the following areas: digital data & RF transmission systems; power distribution subsystems, development & test of complete radar systems, with particular emphasis on doppler navigation & monopulse tracking systems testing & development in RFI phenomena to minimize conducted & radiated electrical interference.

Spacecraft Systems Simulations Engineers—BS degree & fluid/mechanical systems simulation experience required. Responsibilities will include: Support of LEM mission control operations; determination of system malfunction implications; assist in preparing exercises & training simulations; setting up operational procedures; manning simulations console. Work will be performed in Mission Control Center at Houston, Texas.

Spacecraft Mission Control Engineers—Opportunities exist in a small group responsible for flight control operations & fluid/mechanical systems test monitoring. Duties involve planning, preparation for & monitoring of vehicle fluid/mechanical systems flight tests during space development missions. BS degree & thorough knowledge of one or more of the following required: propulsion system test; crew systems test; environmental control systems test. Work will be performed in Mission Control Center at Houston, Texas.

Advanced Systems Test Operations Engineers—BS or MS degree with experience in advanced systems & preliminary design. Will initiate & develop test operational concepts for current & future spacecraft development programs including: conducting studies; organizing, writing & editing proposals; preparation of presentations; & determining customer requirements.

Spacecraft Systems Checkout & Development Test Engineers—BS degree required with pertinent experience in checkout tests of spacecraft fluid/mechanical systems particularly in the areas of: Environmental control & life support systems, liquid rocket propulsion systems & structural/mechanical systems. Will work in an expanding group covering all phases from test planning & generating test procedures information to final systems checkout or development tests. Long term field assignments will be made to either Cape Kennedy for LEM prelaunch checkout or to MSC, Houston for LEM system development tests.

Environmental Control & Life Support Engineers—B.S. in Engineering for assignment in development & design of environmental control & life support systems. Positions also available for non-degree engineers having education & experience in the above & related areas.

Crew Station Designers—B.S. in Engineering for assignment in development & design of cockpit & crew station sub-systems. Positions also available for Engineers having education & experience related to equipment arrangement & support provisions.

Cryogenic Engineers—B.S. in Engineering with experience in development, analysis & design of cryogenic gas storage supply, including related temperature & pressure control systems.

Rocket Propulsion Design Engineers—B.S. in Engineering with experience in one or more of the following areas: Design of liquid rocket motors & related systems; development & design of storable bipropellant rocket systems; gas pressurization & cryogenically fueled power supply systems.

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Applying for position(in)(of)____________________

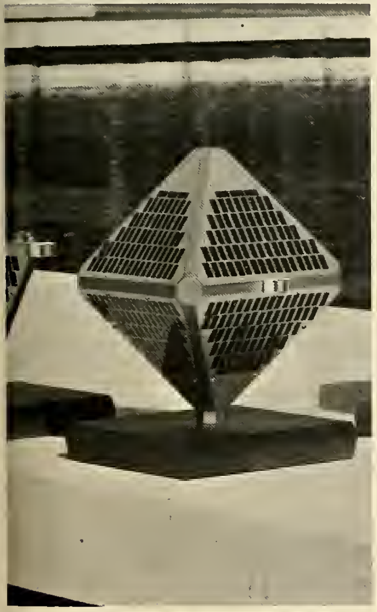
Background and experience (Brief resume of experience, recent history of employment. If available, attach prepared resume.)

C, and *OV2-4* was slated for that job. Now that these *Titan III-C* missions have been cancelled, two gaps appear in the *OV2* number sequence.

OV2-5 is the next vehicle in the series. It is being considered as a possible piggy-back payload in the spring of 1967.

OV3 program—Third member of the family is *OV3*, which is designed as the payload for six *Scout* vehicles owned by OAR. *OV3-1* through *OV3-4* are being built by Space-General Corp. as general-purpose vehicles to serve ARSP. *OV3-5* and *OV3-6* are being built in-house by Cambridge Research Labs.

First flight of the series is planned this spring from the Western Test Range. Two other flights from WTR will follow, but *OV3-4* is scheduled to be launched from Wallops Island, Va.



OV5, built by TRW Systems, is Octahedral Research Satellite covered with solar cells.

OV3-1 will carry experiments sponsored by the Cambridge Research Laboratories, for analysis of the near-Earth charged-particle environment. CRL refers to groups of experiments of this sort as "Cosmic Radiation experiments." The same laboratory is sponsoring experiments of *OV3-2*, which are intended to extend existing knowledge of the electron- and ion-density structure of the outer radiation belt. This group of experiments goes under the heading "space environment."

Experiments on *OV3-3* are sponsored by SSD and are designed to investigate the radiation and charged-particle environment within 2,000 n. mi. of the Earth as a function of time and spatial position. Many of the Aerospace Corp. Space Physics Laboratory experiments carried by *OV2-1* will get another chance on this *Scout*-launched vehicle. Again, one of the chief objectives is to develop an understanding of how charged particles enter and leave regions of magnetic trapping.

The AF Weapons Laboratory will search for more data on personnel hazards associated with ambient space radiation by means of experiments on *OV3-4*. Magnetometers will be used to measure the aspect of onboard sensors.

The Space-General *OV3* is a right octagonal cylinder measuring 29 in. high by 30 in. across the points. Experiment weights vary from 38 to 60 lbs. Gross satellite weights vary from 129 to 165 lbs. It is a spinning satellite that can be de-spun for gravity-gradient experiments.

OV4 program—The fourth member of the series, *OV4*, is an example of an ARSP experiment that consists of a complete satellite in itself. In fact, two satellites are involved: *OV4-1T* (a transmitter) and *OV4-1R* (a receiver). Both are being built by Raytheon for the Avionics Laboratory at Wright-Patterson. They are being flown on the *MOL Gemini* Heat Qualification Test, scheduled for October, 1966. The same launch will carry an integrated OAR experimental package in the mockup *MOL* tank, and also the satellite portion of *OV1-6*.

OV4 is a cylinder with hemispherical ends. Two satellites of this form are separated from each other by a small rocket. As one transmits to the other at various distances, the quality of the transmission is relayed from *OV4-1R* to the ground.

The orbits of the twin satellites will be such that they pass each other twice in 30 days. A follow-on or back-up spacecraft, *OV4-2*, has been procured and could be assigned to another piggy-back flight.

OV5 program—Fifth member of the OAR family is the *Octahedral Research Satellite*, built by TRW Systems Group. Each of these is 9 in. on the side, covered with solar cells, and intended as a secondary payload. Under existing designations, *ORS2A* will carry an experiment for the Rocket Propulsion Laboratory at Edwards AFB, Calif., which is procuring the satellite. Generally, each of these satellites carries one experiment. In this case, a zero-g experiment to investigate heat transfer in a SNAP system is to be flown. RPL has also procured *ORS2B* for a vacuum friction experiment.

OV5-1 is an *ORS* that will function as a solar flare monitoring satellite for Cambridge Research Laboratories. *OV 5-2* is under consideration as a radiation satellite for the Space Physics Laboratory of Aerospace Corp., which will

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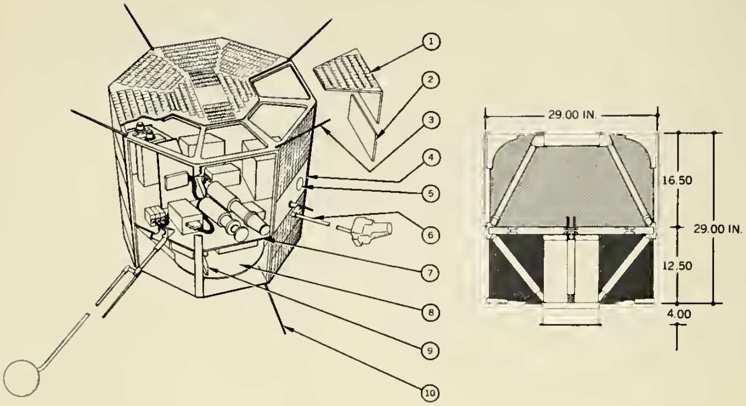

Drawings show makeup of OV3. Numbers indicate: 1) removable honeycomb corner panels; 2) girth solar panels; 3) command antennas; 4) girth band; 5) instrument aperture; 6) folding booms; 7) equipment plate; 8) central cylinder; 9) support; 10) beacon and telemetry antennas. Light area in right drawing is instrument space.

carry out the experiment on behalf of SSD.

Agena flights—The other satellite used by OAR is *Agena*. Generally this carries experiments that do not fit easily into the other vehicles, such as those requiring accurate stabilization.

On *Agena* flights, OAR is one of a number of organizations providing secondary payloads, flown on the *Agena* aft rack. Another user is the Army, which flies geodetic *SECOR* satellites from *Agena*. *Agena* is also likely to be used in the AF Space Systems Division Scientific Experiment Support Program. This differs from ARSP in that it is oriented more towards technology and engineering development.

Since 1959, over 200 experiments have been flown piggy-back on SSD *Agenas*. Over 75% have been successful, in spite of a number of booster or *Agena* failures in the earlier days.

On the *Snapshot 1* flight there were, in addition to the nuclear reactor and ion engine, CRL experiments (density gauge, erosion gauge, micrometeorite detectors, electric structure, and impedance probe), a Lockheed stability-of-surfaces experiment and an Army ionospheric beacon.

On Project Manifold there are 14 experiments, including a potassium boiler, a fuel cell, horizon sensor, satellite yaw sensor, night air-glow measurement, zero-g biocell experiment, a radio noise experiment, and infrared and ultraviolet experiments for Program 461.

Agena target vehicles for *Gemini* rendezvous can also carry piggy-back experiments.

OAR pod program—As of late November, 1965, OAR had flown 24 of GD/Convair's standard pods on ICBM flights, 22 DASA pods, and 4 FLIP pods. The last were part of the Flight Launched Infrared Probe program, carried out under an Advanced Research Projects Agency contract for the Air Force. Four probes, each with a solid-propellant rocket, were built and flown on *Atlas* missiles 135F and 136F. Each probe carried five separate experiments to measure the infrared radiation of the ICBM engine plume.

The DASA pods were initially a series of 16 recoverable types that were flown for Operation Fishbowl during 1962. Six of the recovered pods were refurbished by Convair and reflown to give a total of 22 flights. *Thor* missiles carried the pods aloft from Johnston Island. They were released at altitude to record the effects of a nuclear blast. Twenty pods performed satisfactorily. Sea recovery was effected by a Radioplane recovery system.

The standard scientific passenger pod provides about 30 minutes of zero-gravity and reaches an apogee of 500 n. mi. It weighs about 450 lbs., including 350 lbs. of experiments.

On the *OV1-2* launch the side-mounted pod carried two spectrometers to measure the positive ion composition and density of the upper atmosphere, ion chambers and magnetometers to plot the Lyman-Alpha radiation of the night sky, a sensitive r.f. receiver to measure solar flare noise, and another receiver to measure power line radiation from ground sources beneath the flight path of the pod. ■

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Otolith Function Not Markedly Affected by Weightlessness

ASTRONAUTS appear to have a coordinate space sense with respect to their spacecraft even in weightlessness, if contact cues are adequate. This is the indication of one of the experiments conducted during the *Gemini 5* flight.

These cues, however, apparently were not sufficient in the case of *GT-5* command pilot Gordon Cooper, who consistently reported his position more than 30° off the correct reading.

The conclusion that astronauts can sense their position even in the weightless state, a factor which will become increasingly important in piloting of larger spacecraft, was reported by Dr. Earl Miller, coinvestigator of the M-9 experiment with Dr. Ashton Graybiel.

According to Dr. Miller, it appears that the eight-day spaceflight had no lasting effect on otolith function, as measured by tests before and after the flight. While pilot Charles Conrad had accurate and consistent readings with the experiment equipment during the flight, the command pilot had a marked deviation averaging about 32° in sensing the absolute horizontal.

The M-9 experiment, an outgrowth of the pioneering work done by Dr. Graybiel and his associates at the Naval School of Aviation Medicine at Pensacola, Fla., now sponsored by NASA, consisted of two parts.

Experiment—During the flight, the astronauts conducted an experiment physically incorporated into the onboard vision tester used in another experiment. It used apparatus upward from a custom-fitted bite board, ending in eye cups that excluded all other light. It operated on d-c power from the spacecraft.

The target device the astronaut viewed was essentially a collimated line of light in an otherwise dark field. The line could be rotated about the center with a neural nob. It was equipped with a digital-readout of the line position accurate within ± ¼°.

Although the device was monocular, it was fabricated in duplicate so that the astronaut in the left seat could use his right eye with readout visible to the astronaut on the right, and vice versa.

The instrument also was arranged so that the astronauts had no real knowledge of the correct setting—that is zero was not located at the horizontal—to avoid their learning from the experiment.

This experiment is similar to one often used on the ground, and which has been extensively tested by Dr. Graybiel with deaf persons who lack proper labyrinthine function.

In the normal gravity environment, the researchers say, the normal subjects put on centrifuges and, receiving an additional g force, find that the collimated line tilts at 45°. However, the normal subject can set it so that it appears horizontal or perpendicular to the resultant force.

Deaf or labyrinthine-defective subjects in normal gravity, Graybiel found, do not perceive the movement of the line, indicating that the lack of otolith function interferes with their perception of position or force of gravity.

The scientists wanted to learn what lack of gravitational force would do to the astronaut's ability to sense the horizontal using only secondary cues.

During the flight, the test was conducted by having the other astronaut offset the line. The astronaut taking the test attempted to adjust it until it reached a point he thought represented horizontal. When he removed his hand from the instrument to signal that he was ready, the other astronaut recorded the number on the dial.

The test was not conducted according to the five times daily schedule originally planned during *GT-5* because of the power consumption problem. However, it was held on the 24th, 39th and 54th revolutions and five times immediately after the 72nd revolution.

No system error—While the error by Cooper seemed consistent enough to suspect a systematic failure, this was ruled out for several reasons. The same device had been used in postflight tests, and his measurements were found to be in range. The instrument was tested and found accurate.

The possibility that Cooper's head position was at fault was ruled out because it was found that he could not possibly incline his head 32° while taking the test. In his debriefing, it also was ascertained that he understood the test and there was no misunderstanding leading to the error.

The conclusion, Miller said, was that in the absence of gravitational and visual cues, the cues furnished by contact with the spacecraft did not allow him the correct perception of the cabin vertical.

No lasting effects—The second phase of the experiment was determining whether long-duration spaceflight leads to any permanent effect on the otolith function. This was determined through the use of a counter-rolling test both before and after the flight, since the equipment was too big to be carried onboard.

The test is based on previous Graybiel work which established that when a person in normal gravity is tilted, his eyes rotate in the opposite direction. Labyrinthine-defective subjects do not manifest this response, Miller said.

The device, used at Cape Kennedy before *GT-5* and on board the carrier after recovery of the pilots, had a camera system to record the movement of the astronaut's eyes.

The subject is held on the device in a standing position and rotated laterally about the optic axis of the camera system, and when properly adjusted also rotated about the optic axis of his right or left eye. The recording equipment again was held by a bite board to maintain the same position in front of his eyes.

A triaxial accelerometer unit was mounted on the headboard of the tilt or counter-rolling device, to sense and relay signals of linear acceleration to a recorder. This was installed because the ship provided an unstable platform.

Also, for the carrier tests after the flight, a special cubicle was installed to insulate the subjects from outside cues.

Preflight tests were conducted at Cape Kennedy 16 days before the flight. The astronauts were given a drop of a compound to diminish normal oscillations of the eye that might influence the test, and placed upon the counter-rolling device.

It was discovered during preflight tests that the two *GT-5* pilots, although falling within a random population distribution, had below-normal counter-rolling levels. While at first the researchers thought that perhaps this might be typical of the astronauts from their experience, this was disproven by testing six more of the astronaut group.

Post-flight results did not differ significantly from the preflight scores, Miller reported. ■

A new generation instrumentation radar, developed for Bureau of Naval Weapons, is being readied for the Pacific Missile Range. Sperry's AN/FPQ-10 microcircuited, solid-state C-Band radar offers improved reliability and versatility, obsoleting existing systems. Building-block designed for a variety of configurations and modifications, the FPQ-10 achieves compactness without sacrificing ease of maintenance. A precision radar, it uses a unique two channel monopulse technique, eliminating interchannel phase shifts and permitting operation even with one channel failure. □ The human-engineered console permits control and key function monitoring by a single operator. Complete flexibility allows transmission/reception of any linear or circular polarization, with polarization alternation capability. Write: Marketing Manager, **RADIATION DIVISION, Sperry Gyroscope Company, Great Neck, New York.**

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The Industry Week

Mergers and Acquisitions

TRW, Inc., Cleveland, and its subsidiary, Ramsey Corp., Manchester, Mo., have purchased all outstanding shares of Societe d'Esploitation des Brevets Gemmer (Gemmer-France). Purchase price was estimated at more than $3 million. The company supplies manual and power steering gears. It will be consolidated with TRW's international automotive division. . . . *Mesa Scientific Corp., Santa Ana, Calif., has been merged into its parent company, Planning Research Corp., Los Angeles. PRC purchased Mesa last August.* . . . North American Electronics, Inc., West Lynn, Mass., has been merged into its parent company, IRC, Inc., Philadelphia. Formerly a wholly owned subsidiary, NAE will now be known as IRC, Inc., Semiconductor Div.

International

General Electric Co. and Compagnie des Machines Bull, France, plan to double their investment in the jointly owned Compagnie Bull-General Electric, a French computer concern. New shares are expected to be issued in February that will double Bull-GE's capitalization to about $88.8 million. Shares will not be offered to the public. GE will continue to hold 51% interest in the firm.

New Activities

Federal Mogul Corp.'s Arrowhead Products Div., Los Angeles, has formed a new research and development group to separate in-house R&D efforts from contract-associated work. The initial six-man team for company-supported R&D will be headed by Robert Trelease. . . . *The American Institute of Aeronautics and Astronautics has established a Technical Subcommittee on Computers. Purpose is to facilitate technical advances and reduce duplication of effort by encouraging information transfer between the aerospace sciences and the computer sciences. Chairman is Barry Boehm of The Rand Corp., Santa Monica, Calif.* . . . Physical Sciences Corp., Arcadia, Calif., has formed a new branch in Fairlawn, N.J. Eugene Hicks will head the office. The company produces ultra-high-performance materials and devices for aerospace and nuclear applications. . . . *Nuclear Utility Services, Inc., Washington, D.C., has changed its name to NUS Corp. The move is a result of a broadening of the firm's consulting and engineering services into non-nuclear fields.* . . . Rocket Research Corp., Seattle, has opened a hydrazine technology laboratory in the South Park area of Seattle. The facility is equipped with outdoor rocket test stands for measuring performance of hydrazine control rockets. . . . *Radiation, Inc., Melbourne, Fla., has consolidated its industrial operations into the Control/Communication Div. The change merges the Control Systems Div. and the Products Div. "to provide a broader base for expansion of Radiation's commercial electronics business."* . . . Hughes Aircraft Co., Culver City, Calif., is establishing a new missile systems division in Canoga Park, Calif. Initial personnel will be transferred from the firm's aerospace group about April 1. Warren E. Mathews has been named manager of the group.

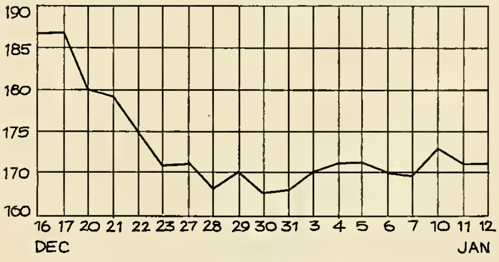
Facility Expansions

North American Aviation, Inc.'s Los Angeles Div. has announced plans for a long-range program of machinery procurement and facility expansion. The firm plans to establish prime structural machining responsibility at Los Angeles for the company's California divisions. . . . *Dow Chemical Co., Midland, Mich., has announced plans to spend $38 million on capital construction in the Midland area during 1966.* . . . Philco Corp.'s solid-state products operation has moved into new facilities in Spring City, Pa. The group is one of the operations within the Lansdale Div., and was formerly headquartered at Lansdale, Pa. . . . *Goerz Optical Co. is constructing a new manufacturing plant to house its Systems Div. near Pittsburgh. The facility will be used for manufacture of instruments for inertial guidance testing, missile tracking, aerial reconnaissance and mapping.* . . . Andersen Laboratories, Inc., has started construction of a 43,000-sq.-ft. plant in Bloomfield, Conn. The $1-million facility is scheduled for completion in June.

Industry Representatives

El-Tech Manufacturing Co., Inc., Bridgeport, Pa., has named the Biztek Co., Beverley Hills, Calif., sales representatives in California, Nevada and Arizona. El-Tech is a supplier of all types of integrated circuits. . . . *Republic Electronics Corp., Paterson, N.J., has appointed Victor Sales, Inc., Belmont, Mass., sales representative in New England. Comp-Tech Sales, Riverdale, N.J., will represent the firm in northern New Jersey, New York City and Long Island.* . . . Fairchild Semiconductor has extended the franchise of Avnet Electronics to market Fairchild transistors, diodes and integrated microcircuits in southern California. Avnet has established a new office in Culver City, Calif.

Missile/Space Stock Index



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
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AIR FORCE

$13,811,030—North American Aviation, Inc., Anaheim, Calif., for components for an improved *Minuteman* missile guidance system.

$4,000,000—General Electric Co., New York City, first segment of a $15.5-million contract for development work on a new propulsion system.

$3,200,000—Bell Aerosystems Co., Buffalo, N.Y., for continued work on prototype rocket engines.

$2,066,537—Aerojet-General Corp., Sacramento, Calif., increment for maintenance and acceptance testing of *Titan II* propulsion systems.

$1,108,000—North American Aviation, Inc., Anaheim, Calif., increment for maintenance and repair of *Minuteman* guidance and control equipment.

$672,291—Texas Instruments, Inc., Dallas, for Project *Vela* research for the Advanced Research Projects Agency.

$516,763—Aerojet-General Corp., Liquid Rocket Operations, Sacramento, Calif., for investigation of heterogeneous propellant two-phase flow criteria.

$400,000—Hughes Aircraft Co., Ground Systems Group, Fullerton, Calif., for program definition phase study for re-entry system evaluation radar.

$385,000—Sperry Rand Corp., Sperry Gyroscope Co. Div., Great Neck, N.Y., for program definition phase study re-entry system evaluation radar.

$325,954—Fairchild Hiller Corp., Stratos Western Div., Manhatten Beach, Calif., for replenishment spare parts in support of *Titan II* missile.

$263,830—United Technology Center, Sunnyvale, Calif., for study of a better technique for fabricating large steel rocket cases.

$249,741—Lockheed Propulsion Co., Redlands, Calif., for characterization and evaluation of light metal hydrides. Also, $139,203 for kinetics of decomposition of solid oxidizers.

$237,346—Bendix Corp., Bendix Radio Div., Baltimore, for ground/air/ground and air/air VHF teletype communication via a synchronous satellite.

$153,224—IIT Research Institute, Chicago, for continuation of research on advanced oxidizer chemistry.

$150,686—Litton Systems, Inc., Beverly Hills, Calif., for continuation of research on electromagnetic plasma production and acceleration.

$74,752—TRW, Inc., Redondo Beach, Calif., for continuation of research on properties of accelerated plasmas.

$73,362—Radio Corp. of America, Defense Electronic Products, Camden, N.J., for microwave microelectronic communication satellite repeater.

ARMY

$3,394,665—Martin, Zachry Constructors, Honolulu, Hawaii, for construction of *Nike-Zeus, Nike-X* and Press (Pacific Range Electromagnetic Signature Study) facilities at Kwajalein Atoll, Marshall Islands, Pacific.

$3,200,000—Technical Operations, Inc., Burlington, Mass., for scientific and operations research for Combat Development Command.

$2,851,100—Avco Corp., Cincinnati, Ohio, contract modification for operation, modification and maintenance of missile tracking and instrumentation radars and interfacing equipment at White Sands Missile Range.

$1,997,060—Bell Aerosystems Corp., Bell Aerosystems Co. Div., Buffalo, N.Y., for exploratory development of an individual lift device system.

$1,900,000—Philco Corp., Philadelphia, to provide an electronic communications switching system.

$1,555,530—Raytheon Co,. Andover, Mass., for *Hawk* missile system ground support equipment. Also, $194,698 for *Hawk* retrofit kits and $1,073,272 for *Hawk* system field service documentation.

$684,371—Aircraft Armaments, Inc., Cockeysville, Md., for FY 1966 *Nike-Hercules* engineering services and technical publications.

$52,291—Radiation, Inc., Melbourne, Fla., modification to perform type 1 tests at Army satellite communications terminals at Fort Dix, N.J., and Camp Roberts, Calif.

NAVY

$12,000,000—Hughes Aircraft, Culver City, Calif., increment for continued work on *Phoenix* missile system.

NASA

$7,837,000—Radio Corp. of America, Aerospace Systems Div., Van Nuys, Calif., for logistic support of *Saturn* ground computer checkout systems.

$600,000—Allied Research Associates, Inc., Aracon Geophysics Div., Concord, Mass., for the operation of the *Nimbus* Data Utilization Center at Goddard Space Flight Center.

$501,200—TRW, Inc., Redondo Beach, Calif., from Goddard Space Flight Center, for orbital operational support for *OGO-A*, Band C.

$495,300—Hughes Aircraft Co., Culver City, Calif., from Goddard Space Flight Center for an engineering model of a high-gain multilobe electronically steerable antenna system.

$483,400—General Dynamics Corp., General Atomics Div., San Diego, Calif., from Lewis Research Center for investigation of materials and components for use in a thermionic space power reactor.

$322,030—Superior Engineering, Ann Arbor, Mich., from Goddard Space Flight Center for grenade payloads and launch.

$273,114—Vitro Corp. of America, Vitro Laboratories, Silver Spring, Md., from Goddard Space Flight Center for technical services for *Apollo* range ships program evaluation of test data. Also, Vitro Electronics, Silver Spring, Md., $27,228 from Goddard Space Flight Center for telemetry receivers and connectors.

$267,663—ITT Industrial Labs., Fort Wayne, Ind., from Goddard Space Flight Center for a day-night high resolution infrared radiometer employing two-stage radiant coating.

$143,332—Livingstone Electronic Corp., Montgomeryville, Pa., from Lewis Research Center for low temperature battery.

$64,945—Lawrence Systems, Ambler, Pa., from Lewis Research Center for servo systems test assembly.

$53,808—Aerojet-General Corp., Nucleonics, San Ramon, Calif., from Lewis Research Center for study of thermal gas-cooled reactor technology.

$49,700—Lockheed Aircraft Corp., Palo Alto, Calif., from Goddard Space Flight Center for investigation of roll resonance phenomena for sounding rockets.

$48,862—Applied Magnetics Corp., Santa Barbara, Calif., from Goddard Space Flight Center for improvement of magnetic recording heads through use of new and refined materials.

$48,650—Canadian Commercial Corp., Ottawa, Canada, from Goddard Space Flight Center for 30-ft. self-extendable boom.

$43,390—Boeing Co., Aero-Space Div., Seattle, Washington, from Lewis Research Center for *Lunar Orbiter* shroud system.

INDUSTRY

$1,000,000—Whittaker Corp., Los Angeles, from **Boeing Co.,** Aerospace Div., New Orleans, La., to produce pre-valves for the *Saturn V* first-stage booster.

$400,000—Ampex Corp., Redwood City, Calif., from the **Jet Propulsion Laboratory,** Pasadena, Calif., for magnetic tape recorders for NASA's *Lunar Orbiter* program.

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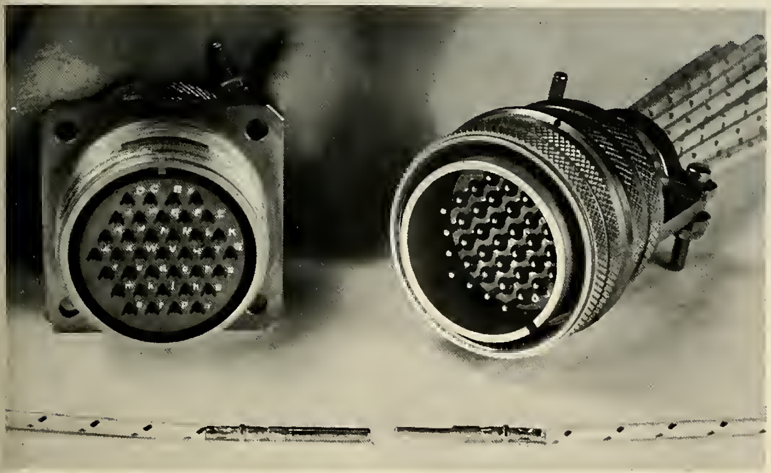

New Product of the Week:

High-Temperature Connector

Use of resilient sealing monomers for interfacial sealing and shell "O" rings at the coupling surfaces provide Amphenol Corp.'s Class K connector with outstanding environmental performance. Contacts and wiring are individually sealed by elastomer grommets.

By use of this construction, the connectors can withstand MIL-C-26500 environments and meet flame requirements of MIL-C-5015. They meet operating temperature requirements of 200°C for 1,000 hours continuously, and short-time exposures up to 800°C.

The units are also able to take thermal cycling from —55° to 260°C and are resistant to moisture, ozone, and corrosive environments.

The rear sealing grommet of the connector has three sealing risers that provide a jacket around individual wires. These sealing members are made of flame retardant silicon elastomer capable of withstanding the design temperature limits.

The male insert assembly is a bonded monoblock construction consisting of three components: a resilient male front insert, a male contact-retaining disc with shrouded individual contact-retaining members, and a resilient rear wire sealing grommet.

The female insert assembly is also bonded monoblock construction consisting of three components. The dielectric insert body is made from a high-temperature ceramic molding that resists 2,000°F flame penetration. The retaining member and resilient sealing are as in the male insert assembly. Shell hardware can be stainless steel or cold-rolled cadmium-plated steel.

Mating face of the female insert body has the closed entry design called out in MIL-C-38300. The face of the hard ceramic insert encloses the front of the socket contacts and provides lead-in chambers to guide the mating pin contacts. If a male contact is bent or misaligned, the lead-in chambers realign the contacts during mating.

Circle No. 151 on Subscriber Service Card

Linear Gate

A linear gate and stretcher providing both fast and stretched outputs has been announced by Chronetics, Inc.

Model 116 is fully RF-shielded and will accept signal inputs of any waveshape, either polarity, 2 nanosecs. or wider, and gate inputs 5 nanosecs. or wider. Gate response is less than 2 nanosecs. It reproduces the gated input with a linearity of ±2% and provides both positive and negative shaped outputs whose amplitudes are linear with respect to the input ±1%. Both signal and gate inputs are dc-coupled and reflections at both remain within ± 10% whether the gate is open or closed. Gate pedestal is adjustable through zero.

Clipping is provided for both inputs and outputs. A pushbutton permits identification of the gate period, and a toggle switch allows manual control of the gate when desired. Stretched output rise time is set at 250 nanosecs. Decay may be switch-selected to 3 or 10 μsec.

Circle No. 152 on Subscriber Service Card

Junction Hotbox

Controls Div. of Research, Inc., has announced a universal reference junction hotbox.

The device holds up to 102 junctions (51 thermocouple pairs) at exact reference temperature (150°±¼°F). It is designed to permit instant connection of all types of thermocouples interchangeably and in any assortment, eliminating need for special compensators or wire-matching plugs. Models are available with continuous ungrounded shields for each of 42 thermocouple pairs.

Circle No. 153 on Subscriber Service Card

Temperature Transducer

An immersion temperature transducer, with a response time from 100 to 150 millisecs., has been developed by Winsco Instruments & Control Co., Inc.

The Model 2964-I uses a platinum wire element. Resistance temperature curve conforms to the Callendar Van Dusen equation, the firm says. Accuracy is ±0.1°F.

The unit is hermetically sealed and designed for resistance to salt water, propellants, hydraulic fluids and other severe environments. It is being qualified for a variety of oceanographic applications as well as flight hardware.

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names in the news

EVANS

WILSON

DUNLAP

PERTSCHUK

William G. Evans: Appointed director of engineering for the Philadelphia division of Honeywell, Inc. **Robert W. Moe** was named manager of the control computer department.

William R. Wilson: Elected vice president of Lockheed Aircraft Corp. in charge of public relations. He was head of the corporation's Washington, D.C. office.

W. Crawford Dunlap: Elected to the board of directors of the Institute of Electrical and Electronics Engineers. He is assistant director for electronic components research at NASA's Electronics Research Center.

David W. Pertschuk: Named director of operations for Fairchild Hiller Corp. He previously held the position of director of reliability and quality assurance for the company.

Robert G. Brown: Appointed vice president-manufacturing of the Wellman Bronze and Aluminum Co. **J. D. Melgaard** was named vice president-sales, and **J. Herbert Burling,** vice president-finance.

Andrew Lozyniak: Elected president of the Fermont Div. of Dynamics Corp. of America.

Millard E. Price: Elected a corporate vice president of TRW, Inc. **Charles R. Allen** will succeed him as corporate controller.

Joseph E. Connolly: Appointed a vice president of Harbridge House, Inc. Four others were also appointed vice presidents: **Francis J. Kelley, Jr.; Richard A. Koplow; Henry H. Norwood,** and **J. William Widing, Jr.**

Walter J. Kudlaty: Named vice president in charge of engineering by Marvel Engineering Co. He is vice president of the Fluid Power Society.

Richard O. Stephenson: Appointed vice president, research and development, of Digital Development Corp. He will be responsible for the company's research programs in advanced memory devices and engineering activities associated with all company products.

Matthew Dorenbosch: Named a senior vice president of North American Philips Co., Inc. **Russell G. Pelton** was also named a senior vice president.

George C. Bornscheuer: Named director of the Burns and Roe, Inc., Washington, D.C. office. He will be responsible for administration of all Washington operations, including power, defense, aerospace and industrial projects.

Col. Lloyd L. Rall: Assigned as deputy assistant director of mapping, charting and geodesy, Defense Intelligence Agency. He will succeed **Col. Leonard L. Haseman,** who is retiring from active service.

Russell W. Harter: Named chief mechanical engineer of Washington Technological Associates, Inc. **J. Louis Peeler** was named chief electronic engineer.

Francis S. Johnson: Named recipient of the 1966 Space Science Award by the American Institute of Aeronautics and Astronautics. He was the first man to recognize that the outermost part of the Earth's atmosphere is enveloped in hydrogen.

Col. Joseph E. Andres: Named deputy for subsystems and equipment management at Aeronautical Systems Div., Wright-Patterson AFB, Ohio. He will be responsible for all phases of the acquisition of government-furnished aerospace equipment for installation in weapons systems.

George J. Howick: Appointed director, technology utilization division, of the National Aeronautics and Space Administration. He succeeds **Richard L. Lesher,** who has been serving as acting director of the division.

Arthur T. Bourgault: Elected president of Haveg Industries, Inc. He succeeds **John H. Lux,** who has resigned to accept the presidency of Ametek, Inc.

John Cirillo: Appointed director of engineering of Walter Kidde & Co., Inc. He will be responsible for all research and engineering activities conducted at the Belleville and Bloomfield, N.J., and Westerly, R.I. facilities of the company.

William F. Fantone: Named director of engineering of the Electronics and Information Systems Div. of Fairchild Hiller Corp. **William F. Vetter** was named director of advanced engineering. Both men previously held management positions with Republic Aviation Corp. before the merger of Republic and Fairchild Hiller.

missiles and rockets
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JANUARY

Society of Plastics Engineers Regional Technology Conference, sponsored by the Cleveland Section, Sheraton-Cleveland Hotel, Cleveland, Jan. 20.

Third Coral Gables Conference on Symmetry Principles at High Energy, sponsored by the University of Miami, Air Force Office of Scientific Research, Atomic Energy Commission, National Aeronautics & Space Administration, National Science Foundation and Office of Naval Research, University of Miami, Coral Gables, Fla., Jan. 20-22.

Third Aerospace Sciences Meeting, sponsored by the American Institute of Aeronautics & Astronautics, New York City, Jan. 24-26.

National Symposium on Tests for Fire Resistance of Hydraulic Fluids and Lubricants, sponsored by the American Society for Testing and Materials, Jung Hotel, New Orleans, La., Jan. 24-25.

1966 Annual Symposium on Reliability, co-sponsored by the American Society for Quality Control, Institute of Electrical and Electronics Engineers Reliability Group, the Institute of Environmental Sciences, and the Society for Nondestructive Testing, Sheraton-Palace Hotel, San Francisco, Jan. 25-27.

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Crisis of Credibility

THE ADMINISTRATION is facing for the first time confrontation with a Congress which finally and demonstrably has lost confidence in the operation of the Dept. of Defense.

Not only is the honeymoon over but the question of divorce must be faced. Congress too long has been treated as an inept, bumbling checkwriter. Patience has run out.

The clash has been almost inevitable. A Secretary of Defense who has refused to accept the judgments of the nation's military leaders on many critical issues has as firmly rejected the views of Congress on many of those same issues.

Secretary Robert S. McNamara went through a long period as a golden boy on the Hill. Cost-conscious and efficient, he was firm in carrying out the intent of Congress, as expressed in legislation, that the Dept. of Defense be unified under civilian leadership.

Disillusionment first began to set in with award of the controversial TFX swing-wing fighter contract. Not only was there discontent in the military about the concept of a multi-service fighter, but there was considerable question about award of the contract to General Dynamics instead of the Boeing Co.

The fact of the matter was that by the time the competition ended, there was not all that much difference between the two proposals. There is little doubt in the minds of qualified observers that either General Dynamics or Boeing was qualified to build the TFX. In that situation, there is also little doubt that the White House played a role in the decision on the award.

Without question, the Secretary never would have condoned award of a contract which would have resulted in an inferior product or inefficiency in production. But with two such able competitors and proposals so nearly identical, he could view with equanimity a political decision in favor of either.

Unfortunately, he was placed in a position of having to retroactively prove that the General Dynamics proposal was more attractive, not to the White House but to the Dept. of Defense. His policy that defense contracts were above partisan politics rested on this. The public contortions forced upon DOD by this untenable situation did much to dampen the enthusiasm of Congress for Mr. McNamara.

The Secretary's adamant refusal to spend funds which Congress allocated for the B-70 bomber also did not set well. Again, his view on the B-70 itself was fundamentally a correct one. But he was equally firm in his stand that no other follow-on to the aging B-52 was immediately desirable. Congressional advocates of a mixed strategic force felt that entirely too much dependence was being placed on missiles. In the context of this discussion, it matters little whether the Secretary was right. Right or wrong, he made powerful enemies on the Hill as a result of his decisions.

The situation was not helped by continuing reports that the TFX test program was having problems. While these are normal in any development program, they were seized upon in this case as evidence that the multi-service fighter decision was a mistake.

There were other actions which irritated the Congress. His decision to phase out a large part of even the current bomber force in favor of missiles was one. Presentation of the TFX as multi-mission in addition to multi-service won no friends for what now is a B-111 as well as an F-111. The manner as well as the fact of the latest base closings aroused further resentment. We have lauded his courage and economy in closing unneeded bases but this courage resulted in new grievances in the legislative branch.

NOW, ANOTHER DECISIVE date has passed. After an early look at the Vietnam fighting, Secretary McNamara predicted that American forces could return by the end of 1965. Perhaps such a forecast could be excused from one who was purely and simply a Secretary of Defense, but it hardly improves the rating of a man who stands as a senior adviser on foreign affairs to the President.

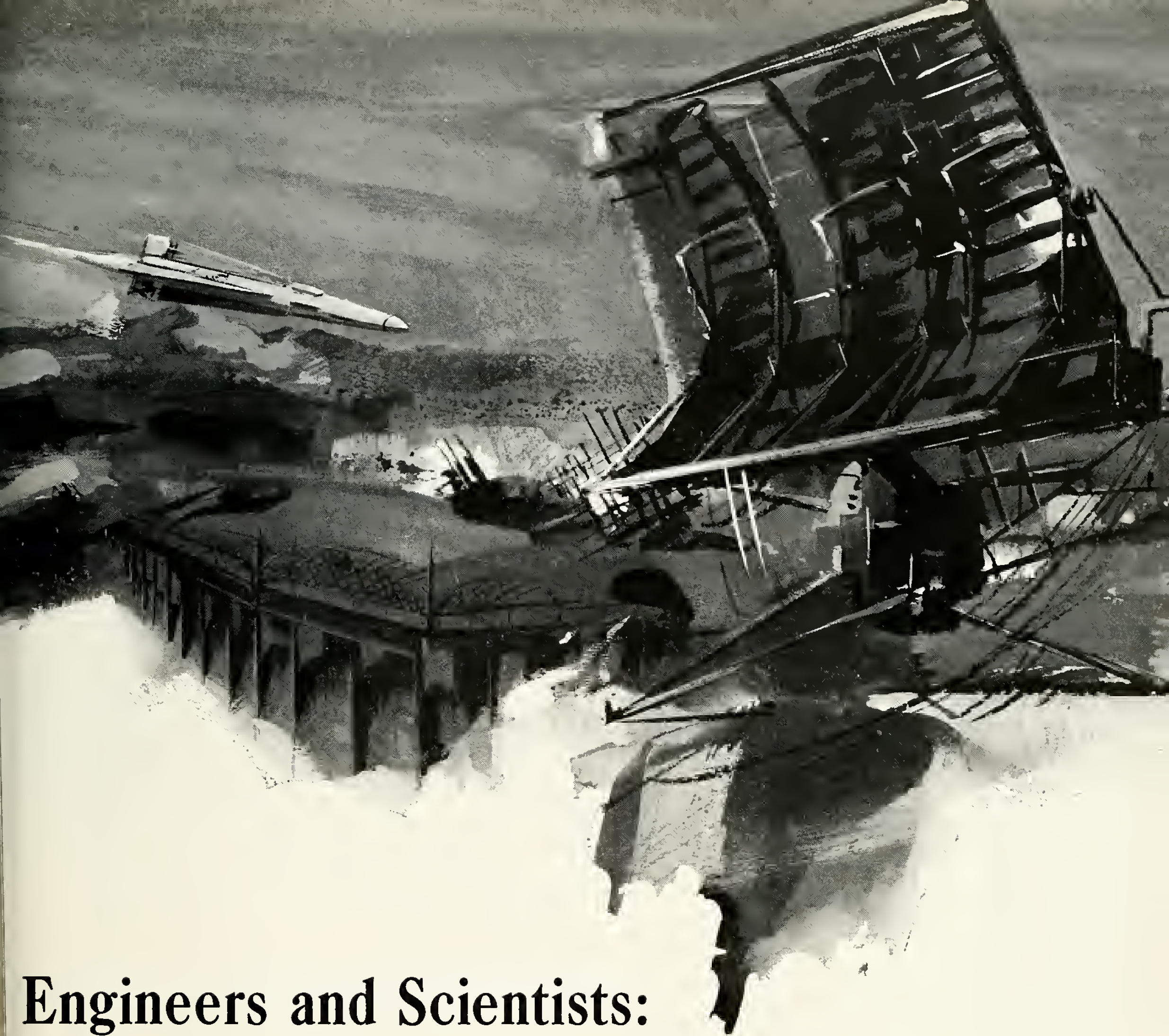
But the major reason for Congressional discontent with the Secretary lies not merely at his doorstep but that of the entire Administration. Since the Cuban missile crisis and throughout the invasion of the Dominican Republic and the Vietnam escalation, the Administration has been less than frank with the American people in regard to the facts behind its actions.

Columnist Walter Lippmann had this to say last week on the same subject: "The contradiction between the briefings and the facts, as they have gradually become visible, has undermined public confidence. The grim truth is that by conducting the war furtively there has developed, as Ambassador Goldberg confessed the other day, a crisis of credibility. People do not know what to believe about what they hear from the White House, the State Department, the Pentagon and the public relations officers in Saigon."

We warned of just such a development at the time of the Cuban crisis. Congress and thoughtful members of the American public now have the uneasy feeling of being played for gullible suckers by experts at the art of flim-flam. However benign the intentions, it is no way to run the republic. A loss of confidence in the truthfulness of the United States government, at home and abroad, is fatal.

In such circumstances, we must welcome not only a forthright investigation of the operations of the Dept. of Defense, such as the House Armed Services Committee is planning, but also a broad Congressional debate of the conduct of the Vietnam affair. Both confidence and credibility are in need of restoration.

William J. Coughlin



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Increasing Air-to-Surface Missile activity at Hughes Aerospace Divisions has created many diversified growth opportunities for qualified Engineers and Scientists. Immediate openings exist at all levels on a variety of interesting projects such as: MAVERICK, Anti-Radiation Missiles, Radar-Guided Missiles and new advanced missile technologies.

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Radar
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Trajectory Analysis
Operational Analysis
Warheads & Fuzing
Structural Design
Thermodynamics
Aerodynamics

All assignments require accredited, applicable degrees, U.S. citizenship and a minimum of 3 years of related, professional experience.

Please airmail your resume to:

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Head of Employment
Hughes Aerospace Divisions
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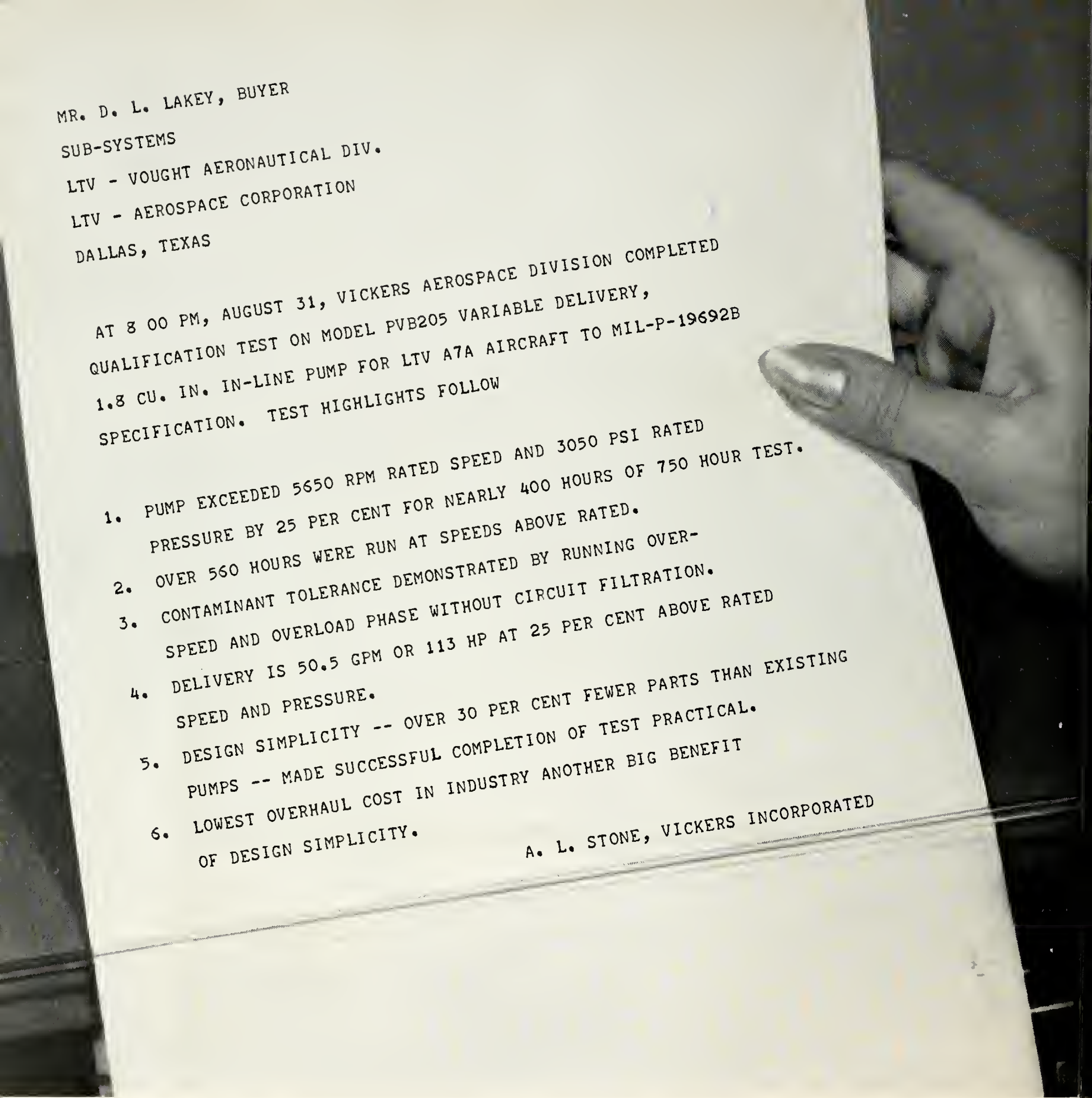

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AT 8 00 PM, AUGUST 31, VICKERS AEROSPACE DIVISION COMPLETED QUALIFICATION TEST ON MODEL PVB205 VARIABLE DELIVERY, 1.8 CU. IN. IN-LINE PUMP FOR LTV A7A AIRCRAFT TO MIL-P-19692B SPECIFICATION. TEST HIGHLIGHTS FOLLOW

1. PUMP EXCEEDED 5650 RPM RATED SPEED AND 3050 PSI RATED PRESSURE BY 25 PER CENT FOR NEARLY 400 HOURS OF 750 HOUR TEST.
2. OVER 560 HOURS WERE RUN AT SPEEDS ABOVE RATED.
3. CONTAMINANT TOLERANCE DEMONSTRATED BY RUNNING OVER-SPEED AND OVERLOAD PHASE WITHOUT CIRCUIT FILTRATION.
4. DELIVERY IS 50.5 GPM OR 113 HP AT 25 PER CENT ABOVE RATED SPEED AND PRESSURE.
5. DESIGN SIMPLICITY -- OVER 30 PER CENT FEWER PARTS THAN EXISTING PUMPS -- MADE SUCCESSFUL COMPLETION OF TEST PRACTICAL.
6. LOWEST OVERHAUL COST IN INDUSTRY ANOTHER BIG BENEFIT OF DESIGN SIMPLICITY.

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Should you have received this message, too?

This is another Vickers first worth noting—the PVB205 is the first pump of any kind to meet the rigid MIL-P-19692B spec.

What's more you get this performance and reliability in a pump that produces significant savings that begin with initial cost and keeps producing through its entire life with lower maintenance costs.

More data is available. You can get it in New Bulletin A-5293, "In-Line Pumps for Aerospace Industry" from: Vickers Incorporated, P.O. Box 302, Troy, Michigan 48084.

VICKERS
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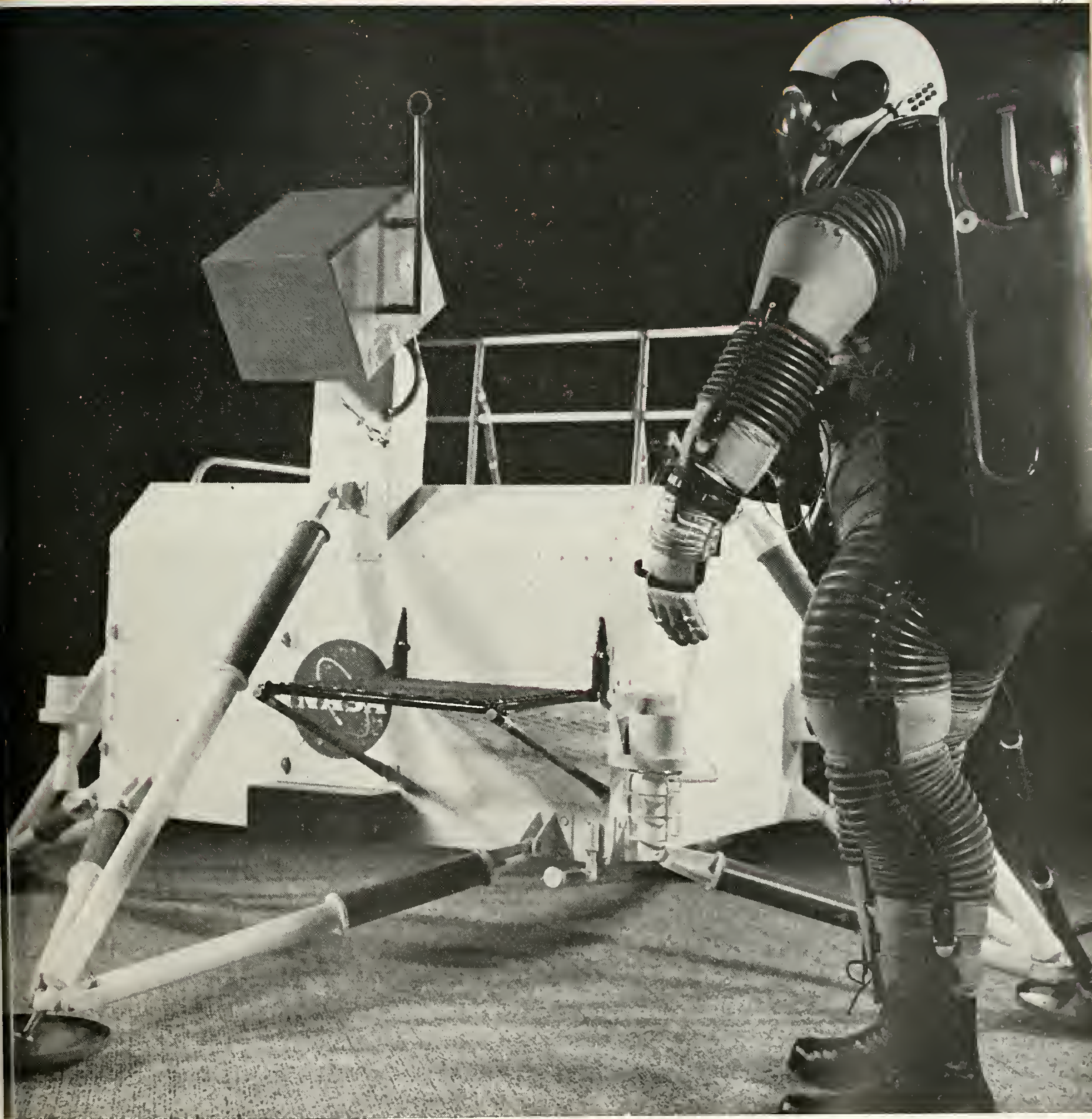
3399

JANUARY 24, 1966

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

JAN 1966
HOUSTON PUBLIC



Mockup of Proposed Lunar Flying Vehicle

Bullpup, Shrike, Hawk Inve

SLBM Defense Moves into

Apollo Tracking Fleet Take

N AVIATION PUBLICATION

Space-Age Boeing Openings for Engineers and Scientists

The Boeing Company's deep involvement in the nation's most important missile and space programs is providing qualified engineers and scientists career opportunities of unusual scope and growth potential. Boeing currently is weapon system integrator for the U.S. Air Force advanced Minuteman II ICBM, prime contractor for the National Aeronautics and Space Administration Lunar Orbiter moon-scanning satellite, and a major contractor on the NASA Saturn V launch vehicle.

160,000,000 horsepower, equivalent to power of 600,000 automobiles, will be generated by S-1C first-stage booster as NASA's Saturn V lifts Apollo off on moon journey.

Aerospace Group assignments, listed in the right-hand column, are in research, design, development, manufacturing and test, and scientific and business computer technology. Requirements include a Bachelor's or advanced degree in an applicable discipline, plus related experience.

Salaries are competitively commensurate with experience and educational background. Moving and travel allowances are paid to newly hired personnel. The Boeing Company is an equal opportunity employer.

Send your resume to the employment manager at the installation(s) of your choice: Mr. L. S. Bonsteel, Boeing Atlantic Test Center, P. O. Box 1698 - MTP, Cocoa Beach, Florida; Mr. John Hall, Boeing Launch Systems Branch, P. O. Box 1680 - MTP, Huntsville, Alabama; Mr. R. A. Garinger, Boeing Launch Systems Branch, P. O. Box 29100 - MTP, New Orleans, Louisiana 70129 or Mr. Lawrence W. Blakeley, The Boeing Company, P. O. Box 3822 - MTP, Seattle, Washington 98124.

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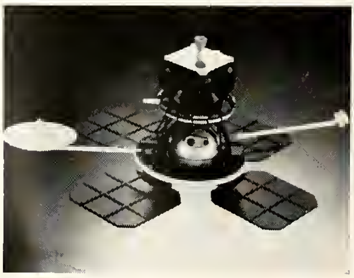
First Lunar Orbiter flight, scheduled for mid-1966, will seek out Apollo landing sites with sharp, detailed photographs of moon's surface. Boeing is building eight Orbiters for NASA.



Assignments are in the following areas:

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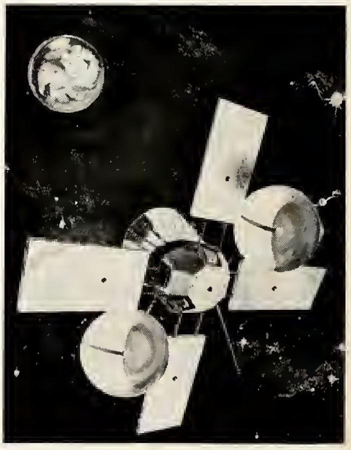
Flight Technology
Telemetry Systems & Design
Electronics Technology
Instrumentation
Propulsion & Mechanical Systems
Scientific Computer Programming
Logistics Engineering
Aerospace Program Planning
Test Engineering
Electrical/Electronic Design
Materials & Processes
Human Engineering
Cryogenics
Weights Engineering
Guidance & Control
Reliability
Service Engineering
Mechanical Design
Structures Analysis & Design
Computer & Logic Circuit Development
Industrial Engineering/PERT
Electronic/Electromechanical Parts Evaluation
Computer Systems Analysis
Plant Facilities Engineering
Manufacturing Development
Welding Process Development
Brazing/Diffusion Bonding
Arming & Fuzing Technology
Tool Design
Quality Control
Management Systems Staff

Artist's early concept of unmanned Voyager spacecraft, which will explore the planets, beginning with Mars in early 1970's. Boeing is one of three companies picked by NASA for preliminary design studies.



missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY
Volume 18, Number 4 January 24, 1966

THE COVER

Full-scale mockup of a lunar flying vehicle now undergoing preliminary tests at Bell Aerosystems, Buffalo, N. Y. Engineers at NASA's Marshall Space Flight Center took a concept originated by Bell for MSFC, modified it, and produced this three-legged design weighing about 400 lbs.

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We're in metals research and development right up to our complex test stands. For example, we are in the midst of extensive company-funded studies for new generation aircraft propulsion components...for the huge, new military transports, business jets, supersonic transports and fighters.

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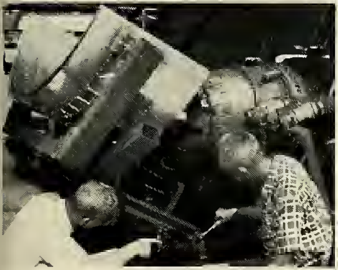
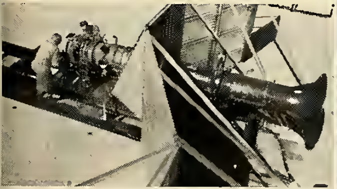
Research and development at Rohr today is a continuing and growing activity. Advancing requirements in propulsion, for example, have led to new research and test facilities and a constant recruitment of personnel in specialized technologies. For Rohr's primary objective is to meet the needs of customers including complete package projects involving research, systems selection and other technical services.



Thermo-cycling test of a titanium-aluminum structure thrust reverser door in the exhaust of a J-34 turbojet engine. This door was subjected to 385 cycles of 15 seconds heating and 75 seconds cooling. The temperature on the face sheet of the door reached 970 degrees F. Data accumulated in these tests will support design efforts on future thrust reverser systems.

J-65 turbojet engine on a unique thrust bed capable of measuring thrust fore and aft, vertically and laterally. The aft portion shown is a Rohr-designed adapter simulating temperature and flow conditions of a turbofan engine. This equipment is being used in tests to develop vectoring for VTOL aircraft.



Hardware adaptation on the J-34 engine, creating a gas generator to test a full size, in-flight thrust reverser designed for use on a supersonic fighter.

For detailed information concerning Rohr's full technical capabilities contact Marketing Manager, Dept. 27, Rohr Corporation, Chula Vista, California.

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letters

The Downhill Path

To the Editor:

I have just completed reading a very thought-provoking editorial in the 10 Jan. 1966 issue of M/R, "The Downhill Path."

Your editorial deserves much praise and congratulations. It pleases me to know that someone has the fortitude to speak out against a growing situation in the DOD and the complete Johnson administration.

I certainly agree that defense contracts should not be used as a political pillory post at the whim of the president, the man that is supposed to be the leader of our country. I feel certain that we will see more of this "political wrist slapping."

Keep up your informative work!! Editorials such as these are much appreciated and enlightening.

Ray D. Kington
Patrick AFB, Fla.

To the Editor:

Congratulations on "The Downhill Path." If we don't keep fighting them, there'll be nothing left pretty soon. Another few years of end before means and we'll all have forgotten what morality, logic and decency mean.

Jules Bergman
Science Editor
American Broadcasting Company
New York City

Letter from the Editor

To the Editor:

It was certainly a relief to learn in your Dec. 20 editorial ("Letter from the Editor") that "peace is no threat to the (missile/space) industry of advanced technology." Yesiree!

R. W. Tate
Des Moines, Iowa

Lunar Crash Program

To the Editor:

Three or four years ago you kindly published a half-serious letter from me asking when the U.S. was going to orbit the Moon. I guess this year or next year is the year we try, but I'm not sure, because "this year" or "next year" has been "the year" each year since 1962.

I am even more puzzled that the Russians haven't accomplished this seemingly straightforward feat. They have been trying on and off since 1959 (with *Lunik III*) to "round" the Moon and haven't succeeded once with *this* "simple" feat, even though they did photograph the back side in 1959.

Maybe orbiting our nearest neighbor isn't really so straightforward after all, but with a twenty billion dollar (ha!) *Apollo* program depending on it, hadn't we better find out for sure before "next year"? By 1968, "next year" will be too late to learn what the problems are. In fact if there are any really significant problems—and I'll bet a fin there are—we're already way too late to meet our commitment for "men on the Moon before 1970"—for whatever that is worth.

I'm all for space science, but I disapprove of the crash schedule for our manned lunar program and disapprove even more of the scanty program of really fundamental scientific studies we are doing and planning to support it. It seems to me that we've been taking far too much for granted!

Albert T. Camp
Indian Head, Md.

The Hogwash Conference

To the Editor:

I want to compliment you on your editorial in the Dec. 6, 1965, issue. I am sure that there are many of us who are aware of the facts that you brought forth, but unfortunately it is all too rare to have the editor of an important magazine "lay it on the line" in the manner you did. I compliment your bravery, as well as your intelligence.

Mr. E. F. Van Nostrand of Edgewood, Md., wrote a letter on this subject in your Dec. 20 issue. His summing up is an excellent supplement to your editorial.

As for the comments of Mr. V. L. Coffield in the same issue, they typify the thinking of his ilk and can best be summed up by the statement which people of his persuasion put out, "better Red than dead."

Daniel P. Green
Duncan, Okla.

Star Sighting Problems

To the Editor:

Your recent article (M/R, Jan. 10, p. 17) on "Star Sighting Difficulties" was read by me with some mixed feelings. Especially disappointing was the reference to the "unexpected" finding of this problem during Project *Mercury*.

My file on this subject begins with a letter to John Glenn on 12 May, 1961. After his answering letter asked for further details, I replied with a full statement of my theory (which was first discussed during a countdown in February, 1961) that, once outside the atmosphere, the naked eye would not be able to distinguish individual stars except as countless, patternless pinpoints of light.

In spite of having made this suggestion, which I felt deserved technical investigation, and having been a Cape employee for many years, with a current security clearance, I have never received a word of indication that it was ever seriously considered.

I would like to take this means of saying to those inaccessible "experts in various disciplines" that there is more to this problem than was hinted at in your article, and that continued minor circular orbital missions in the *Gemini* program will not provide the solution.

Robert B. Wallace
Merritt Island, Fla.

When you get right down to the Moon, Mars and Mercury, we're up to it.

When it comes to some of the most ambitious planet hopping plans around, we are very much part of the scene.

Take our "coolie hat" vehicle concept (known more formally as the "Langley Tension Shell") as a starter. It's designed to land a scientific payload through the ultra-thin Mercurian atmosphere at hyperbolic arrival velocities of more than 20,000 m.p.h.

Our moon plans are further along. In fact, we're under contract to the AEC to build SNAP-27...the first nuclear power system for operation on the lunar surface. It will use Plutonium 238 as the heat source to produce 50 watts of thermoelectric power for experiments conducted by NASA as part of the Apollo Program.

We have designs on Mars. Currently we're working to develop a Voyager bus which could carry a lander there by 1973.

We're also up to many other space projects. Bio-satellite with its crew of monkeys, tradescantia, neurospora and other exotica is slated for several round-trips soon. MOL and its astronauts will see countdown a couple of years later (we were recently selected as a prime contractor). Our simple-bodied Gravity Gradient Stabilization System (1 moving part) has been throwing its brains around for over two years. Other versions are slated for synchronous orbit next year (ATS). And when OAO goes up, it will be oriented by our extremely accurate control system.

Are you interested in IR/optics, simulation, human factors, life support, radar discrimination, structures and weights, reliability, guidance & control, measurements and environments, materials development, spacecraft design, pyrotechnics, structural mechanics, aerodynamics, thermodynamics, flight systems analysis, electrochemistry, flight mechanics, operations research, fluid mechanics, arming & fuzing, nuclear effects?

For further information, write to Mr. J. S. Barson, Dept. 394A-4, Space Technology Center, General Electric Co., P.O. Box 8555, Philadelphia, Pa. An Equal Opportunity Employer (M&F)

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The Countdown

WASHINGTON

DOD Ponders Vietnam SAM Killers

Despite the solid enthusiasm of some DOD officials for exploring use of surface-to-surface missile systems armed with non-nuclear warheads against targets that now require strikes from aircraft (M/R, Oct. 18, p. 18), there is reported to be very little program activity along these lines within DOD. Use of missiles is believed to be especially suitable in attacking enemy surface-to-air missile (SAM) sites. Some officials believe that presence in North Vietnam of an improved version of the currently used Soviet-built SAM could provide the impetus for a development program.

Navsat Group's Report Two Months Away

A special inter-agency committee studying the feasibility and desirability of a navigation satellite system now expects to deliberate for another two months before making final recommendation. The group, composed of representatives of NASA, the Commerce Department, DOD and the Federal Aviation Agency have been at work more than a year, indicating that even if such a system is approved for development the decision would not be an easy one.

Vietnam Helicopter Attrition Is Low...

The Army reports that in four years of helicopter operations in Vietnam, 62 Army helicopters have been lost to ground fire. Since January, 1962, 1.1 million sorties have been flown, making the loss rate from ground fire one in every 18,000 sorties. The hit ratio is reported as one in 450 sorties, with a helicopter going down one out of every 8,000 sorties.

...but War Puts Pinch on Manpower

A report by the Joint Committee on Defense Production now being printed will say that the economy is beginning to show the impact of the Vietnam buildup, and that in areas of heavy defense production the already short supply of manpower may get serious. The committee, chaired by Sen. A. Willis Robertson (D-Va.), also stresses the need for fiscal and monetary policies to reduce the danger of direct controls such as those imposed upon the economy during World War II and the Korean conflict.

Second Scientist-Astronaut Call Due

Second call for scientist-astronauts may be made soon after the fifth group of astronauts named this spring. Only six were named to the program in the original scientist selection last June. The MSC's astronaut selection board is now picking "up to 15" pilot-type astronauts. Six women "expressed interest" in this most recent group but none could qualify under rules set down by the Manned Spacecraft Center.

Apollo Land Recovery Pursued

NASA is starting the first drop tests of a full scale (56-ft. dia.) cloverleaf steerable parachute at El Centro, Calif. The chute will lower a 5,000-lb. "spacecraft" to the ground after it is ejected from a B-66 aircraft. The tests are part of a continuing series to develop an Earth landing system for the *Apollo* spacecraft.

Ramjet X-15 Award Expected in Mid-Year

NASA now does not expect to select a firm to develop ts hypersonic ramjet engine for the *X-15* research program until the middle of the year. Garrett, GE and Marquardt will make oral reports on their nine-month systems-definition and feasibility studies to the Langley Research Center early in February with the final report due around March 1. One of the firms is expected to be selected about three months later for the development contract.

House Action Aimed at Metric System Vote

The House Space Committee has agreed to support the Senate version of a bill calling for study of conversion by the United States to the metric system. Although the committee has its own bill, the move was made in the hope that the Rules Committee will see fit to allow one of the bills to reach debate and a vote on the House floor. The original House bill was put in limbo in the Rules Committee last session.

INDUSTRY

EOS Experiment Selected for Gemini

The first industry-proposed experiment to fly in the *Gemini* series is scheduled for the *Gemini 10* and *11* missions. It is a scientific experiment investigating the plasma wake of orbiting spacecraft in the ionosphere. The sensing instrumentation will be built by Electro-Optical Systems, Inc., Pasadena, Calif., under a $275,000 MSC contract, and will be mounted on the target docking adapter of *Agena* rendezvous vehicles. MSC said measurements will be made of charged particle densities and electron temperatures.

MSC Accepts Environment Chamber

Manned Spacecraft Center has formally accepted the larger of its two space environment chambers (120 x 55 ft.) from Industrial-Fisher-Diversified, prime contractors for the thermal test facility. MSC crews will begin shakedown tests of the chamber within two months. The Army Corps of Engineers, technical monitor for NASA facility construction, approved the chamber's vacuum pumping equipment, cryogenics for cold walls, and repressurization systems. Carbon arc lamps to simulate solar radiation are being installed by Radio Corp. of America, and North American Aviation, Inc., is installing support equipment for *Apollo* spacecraft tests.

Martin-Orlando To Upgrade Pershing

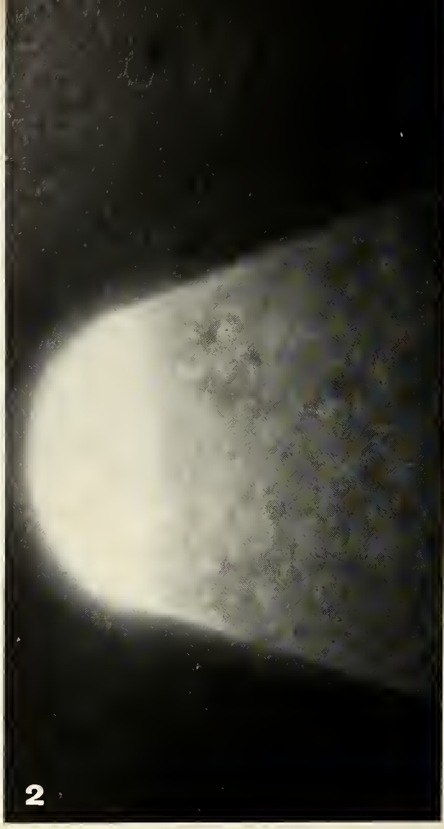
The Army will spend more than $41 million over the next three years to improve the rate of fire and reliability of the *Pershing* missile. Work will be performed at the Orlando, Fla., division of Martin Co., *Pershing* prime contractor. Major system improvement will be centered in a new programmer test station, actually a mobile missile fire-control center, and a new erector-launcher. No changes in the missile are planned.

INTERNATIONAL

ESRIN Begins Operations in Italy

Europe's smaller version of NASA's Goddard Space Flight Center, the European Space Research Institute (ESRIN), has begun operations in a temporary home in the Park Hotel in Frascati, Italy. A center of the European Space Research Organization, it will work initially on plasma physics and its application to spacecraft control, together with plans for the proposed ESRO astronomical observatory. Permanent facilities are planned near the Italian Atomic Energy Authority's research center.

If it's "Beyond the state of the art"...



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As a result of basic research, Solar produces products that require advanced structures or processes, some of which may be considered beyond the present state of the art. Typical projects include: manufacture of prototype jet engine components and space ducting assemblies, fabrication of assemblies containing stainless-to-aluminum joints on a production basis, development work in joining other metals, processes for machining and joining large titanium pressure vessels, development of corrugated tungsten structures in foil gages and tungsten cones for re-entry structures.

Solar also manufactures a variety of lightweight, efficient heat exchangers for airborne applications, including space radiators and cold plates. Jet engine components such as frames, combustors, supports, shrouds and tailpipes have been designed and manufactured for every aircraft engine firm. Combustors, for example, are close tolerance assemblies made up of many parts. Solar is able to fabricate them in large quantities, coat them with Solar's Solaramic® coatings, and deliver them on schedule.

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If you have a problem related to a difficult-to-fabricate aerospace component, or require fast, reliable volume production in the field of metallurgy, write: Solar, Dept. O-122, San Diego, California 92112.

SOLAR
A Division of International Harvester Company

1. Processing of space booster ducting in Solar's LOX cleaning room. 2. Solar-built nose cap of thorium oxide overlay reinforced with a tungsten matrix on a tungsten base. 3. Solar uses electron beam welding to join high alloy and refractory metals.

Circle No. 2 on Subscriber Service Card

The Missile/Space Week

Japan Increasing SAM Sites

Japan's surface-to-air missile sites will be increased to 44 during its third five-year defense buildup program beginning in Fiscal Year 1967.

Four *Hawk* battalions and three *Nike-Hercules* battalions will be deployed in scattered areas of Japanese islands, in addition to two existing *Nike-Ajax* battalions and two *Hawk* battalions. Each battalion will consist of four companies manning different missile sites.

The Japanese Defense Agency plans to purchase *Nike-Hercules* missiles from the U.S. but to buy the *Hawk* missiles from Japanese producers.

Apollo Fuel Cells Under Test

Fuel cells built by Pratt & Whitney Aircraft for the *Apollo* spacecraft are undergoing verification tests at NASA's test facility at White Sands, N.M., utilizing *Apollo*-configured ground support equipment (GSE).

First flight test of the *Apollo* electrical power system is planned during *Saturn-Apollo 202*—an unmanned, near-circular lob shot with splash down near Wake Island in the Pacific. Three cells, each rated at 1.42-kw average power drain and 2-kw peak power drain, will be carried onboard the *Apollo* spacecraft. During peak power operation, such as during mid-course correction, the fuel cells will be augmented by battery power, MSC said.

Tests at White Sands, expected to run through March, will simulate the *SA-202* mission. Cells will be run through 40 hours continuous operation with simulated emergency power operation on two cells and emergency operation on one cell under maximum load.

Foreign Grants Studied

The House subcommittee on research and technical programs will hold hearings Feb. 10 and 24 to determine whether a reduction can be made in the money from federal government grants and contracts supporting research abroad by foreign scientists.

According to Rep. Henry S. Reuss (D-Wis.), over $25 million is being spent to support foreign research projects. The hearings will determine whether this amount can be reduced in order to offset the balance of payments deficit resulting from the Vietnamese war and other foreign activities. If the current levels of foreign research spending are not found essential for domestic research efforts,, a tightening of review procedures for selection of foreign research projects will be considered, said Reuss.

Soviet Spacecraft Designer Dies

Sergei Korolev, the Soviet space scientist who designed almost everything Russia put into orbit, died Jan. 15 at the age of 59.

Under the unassuming title of "chief designer," Korolev designed history's first artificial space satellite, first space ship and first Moon rocket. His valuable role in the Soviet space program was not disclosed until his death.

Korolev was awarded the Lenin Prize and other medals for his work. He will buried in the Kremlin Wall, an honor reserved for only the most prominent Soviet citizens.

Maneuvering Unit Tested

First manned test of the Astronaut Maneuvering Unit (AMU) was conducted at Manned Spacecraft Center's space environment chamber last week.

Maj. Edward Givens, Dept. of Defense project officer on the AMU, entered the chamber, donned the rocket-powered backpack and activated the system. He wore a modernized *Gemini* extravehicular suit specially reinforced to resist damage from plume impingement and the extravehicular activity oxygen chest pack.

The donning procedure—from the time the astronaut enters the adapter until he is cut free to maneuver with the unit—will take from "8 to 10 minutes" during the *Gemini 9* mission, Givens said. After the exercise, the AMU will be either hooked to the side of the retro adapter or pushed away from the spacecraft. Two training sessions with the AMU in the chamber are scheduled for the *Gemini 9* pilots in the near future.

Shots of the Week

The Navy fired a *Polaris A-3* missile Jan. 17 for the rocket's 24th consecutive success in training launches. Launch was from the nuclear submarine Simon Bolivar, submerged 30 mi. off the coast of Florida. The missile traveled 2,500 mi. downrange.

- The Strategic Air Command successfully fired a *Minuteman II* ICBM from Vandenberg AFB, Calif., Jan. 18.
- An experimental missile booster was fired Jan. 13 from White Sands Missile Range, N.M., to conclude the test program for the High-G Boost Experiment (HIBEX). Officials of the Advanced Research Projects

B-47 Carries Navy Drone

Technicians at the Naval Missile Center, Pt. Mugu, Calif., hang the AQM-37A missile target under the wing of a B-47. The launch vehicle was successfully tested over the Pacific Missile Range Jan. 4. It was dropped from the aircraft at 35,000 ft. altitude at a speed of Mach 0.8. The missile climbed to 45,000 ft. and achieved a speed of Mach 1.0

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Agency said all test objectives of the program were met. In the final launch, the booster was fired in a vertical trajectory from above ground.

- Five *Nike-Apache* sounding rockets were launched from Wallops Island, Va., Jan. 17 to study wind speeds and directions. Each rocket was programmed to eject a vapor cloud of a reddish or bluish color. On Jan. 12, NASA and the Brazilian Space Commission fired *Dart* boosters from both Wallops Island and Natal, Brazil. The shots were part of a joint sounding rocket program.

Systems Analysis Grant Let

California will receive a $220,000 federal grant for a new land use study in Santa Clara County, Gov. Edmund G. Brown has announced.

The study is an outgrowth of Brown's four aerospace studies conducted last year utilizing aerospace techniques for the solving of state problems. Most of the work will be done by an aerospace firm. A request for bids will be announced later.

According to the governor, the proposed information system "is only one facet of a total state-county-city information system" proposed by the Lockheed Missiles & Space Co. last year.

NASA Gets Satellite Proposals

The space agency has received proposals from seven firms for a study of a direct broadcast satellite.

Two firms will be selected for six-month studies of two concepts—a spacecraft capable of transmitting in the HF band and one for transmitting in the FM band.

Bidders were Radio Corp. of America, Raytheon Co., General Electric Co., Westinghouse Electric Corp., Fairchild Hiller Corp., Philco Corp., and TRW Systems.

Portable Film Processor Shown

The first completely air-transportable photo-processing facility for tactical reconnaissance film from Air Force RB-66, RF-101, and RF-4C aircraft was demonstrated recently for the first time.

Made up of eight interconnected modules, the equipment is being built by Goodyear Aerospace Corp. and is shippable in C-130 aircraft. Set-up time after landing at forward airstrips and combat zones is less than two hours.

Film from infrared sensors, side-looking radar, frame and panoramic cameras can be developed within an hour, ready for interpretation with the aid of high-speed processing equipment in the modules.

Sixteen of these facilities are being built for Tactical Air Command. Basic module size is 8 x 8 x 12 ft., but some units have expandable sides. The facility demonstrated was produced within six months of contract award.

Lockheed Fires 156-in. Motor

The second-stage flight prototype of Lockheed Propulsion Co.'s 156-in. solid motor was successfully fired Jan. 15 at the company's Potrero, Calif., facility. The test ran 72 secs. for a total thrust of 1 million lbs. Pressure was 655 psi and thrust vector control made three complete cycles, as programmed, Lockheed said. Data on side forces generated by thrust vector control have not been fully analyzed, but indications are they were satisfactory. This was Lockheed's second and final firing under a $5.5-million Air Force contract. The first-stage prototype was fired Dec. 14.

Falcon Modified for AF

Hughes Aircraft Co. is reported to be modifying a large number of early versions of the *Falcon* air-to-air missile (the *GAR-2A* and *-4A*) to the *AIM-4D* configuration, said to be in heavy demand for Air Force tactical aircraft requirements. Contracts are said to total some $70 million.

Hughes has also signed a contract with the Swiss government for a new air warning and weapons control system. The system, to work in conjunction with Switzerland's national force of jet interceptors and surface-to-air missiles, involves long-range 3-D radars, Hughes H-3324 computers, and company-built digital data transceivers.

NASA Receives HL-10

The HL-10 lifting body vehicle was handed over to NASA Jan. 18 by Northrop Corp. in ceremonies at the company's Hawthorne, Calif. plant.

The 22-ft.-long, wingless, tri-finned research vehicle is the second to be delivered by Northrop in the past seven months. The M2-F2 has been undergoing tests at NASA's Flight Research Center since last June.

Renegotiation Actions Reported

The Renegotiation Board made 52 determinations of excess profits during FY 1965 totaling $16.1 million, its annual report said.

In addition, determinations in the amount of $3.3 million had been made by June 30, 1965, although they were not yet incorporated in agreements or orders. Total amount of excessive profits determined by the board since its inception through June 30, 1965, the report said, amounted to $911,941,861.

In Fiscal 1965, contractors reported voluntary refunds and price reductions in the amount of $16.4 million, bringing the total such refunds and price reductions reported since the inception of the Board to $1,246,553,691, the annual report stated.

Reactor Shield Installed

The Atomic Energy Commission is installing a radiation shield around the Phoebus-1B reactor for test firing next summer. Future plans are for larger shields for more powerful engines.

Turnaround time in testing the reactors is expected to be reduced to a few days by cutting down escaping radiation during test. Up to five days delay has resulted because of contamination due to unshielded reactors.

Not only could higher radiation from more powerful reactors extend down time for weeks, but there is also the possibility of heat damage from energy deposited from gamma radiation on steel and other material in the test cell. ACF Industries designed and built the prototype of the shield, which has been tested with a reactor used to check out new Rover reactor designs.

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	AG	3000	7200
Flexural Strength (psi)	WG	4700	8800
	AG	4300	8000
Compressive Strength (psi)	WG	10000	13900
	AG	12000	18000
CTE (in/in/°F x 10^{-7})	WG	22.8	39.5
	AG	27.8	43.9
Thermal Conductivity (BTU-ft/hr ft^2 °F)	WG	90	30
	AG	85	33
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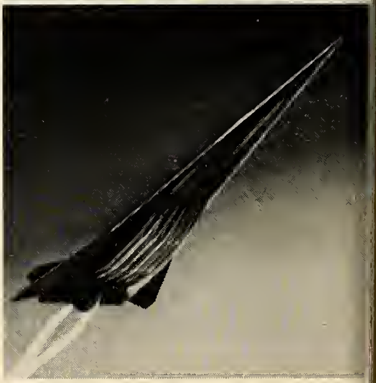

Lockheed's company speedometer spans speed regimes from 0 mph through Mach 12. And the opportunities for engineers interested in programs encompassing these regimes were never more diverse.

In subsonic airborne systems, Lockheed is taking a fresh look at basic problems. For example, it is deeply involved in STOL and V/STOL short-haul transports for mass travel between major cities. In addition, a Lockheed five passenger rigid rotor helicopter prototype is now flying. In the future: heavy-lift helicopters capable of transporting 24,000 or 40,000 pounds for 100 or 200 miles. And under parallel development—advanced rotary-wing craft able to stop, fold, or start blades in forward flight.

Lockheed's supersonic efforts are also expanding. Its SST program alone is a major and growing endeavor. It reflects the unprecedented experience Lockheed engineers have gained in Mach 3, high altitude, titanium aircraft.

Manned hypersonic test and cruise vehicles, using the SCRAMJET approach, are under development at Lockheed. They point to the day when high priority passengers and cargo can travel at Mach 12 speeds to an place on earth.

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Three Missiles Figure in DOD Request

New procurement is for Hawk, Bullpup and Shrike; only $4.6 billion of record supplemental will be spent in FY '66

by Michael Getler

PRESIDENTIAL REQUEST for more than $181 million for additional tactical missile procurement, part of the $12.7-billion Fiscal Year 1966 defense supplemental appropriations bill that went to Congress last week, will be spent for *Bullpup, Shrike,* and *Hawk* missiles.

Total missile procurement portion of the bill includes $64 million for the Army, $26.2 million for the Navy, $27.5 million for the Marines, and $63.7 million for the Air Force.

Defense Dept. officials say a total of 4,830 missiles will be bought with the additional funds. Largest buy will be of the Raytheon-produced *Hawk* surface-to-air defense weapon. *Hawk* and associated spares will account for all the Army and Marine Corps missile request, according to informed DOD sources.

No threat implied—DOD officials say that the additional funds for *Hawk* do not reflect at this point any increased threat from the air against U.S. forces in Vietnam, but are primarily for replenishment of *Hawk* stocks in other locations that had been depleted to meet deployment in Southeast Asia.

The Air Force and Navy figures reflect procurement of both air-to-surface missiles, *Bullpup* and *Shrike,* for both services, in addition to associated spares, and some funding for aerial targets for both services.

Additional production of *Bullpup,* probably the *"C"* version, is expected to reopen the competition for production of the missile from its current sole-source status with Maxson Electronics (M/R Oct. 11, p. 9) if schedules allow.

Production of the *Shrike* anti-radiation missile, an improved version reflecting increased reliability over earlier production models, had also been anticipated (M/R, Jan. 10, p. 9). Both Texas Instruments and Sperry now hold production contracts for *Shrike.*

DOD officials state that within the supplemental the total request for additional conventional ammunition is $2.1 billion.

The FY '66 supplemental also includes a request for just under $3.2 billion for additional tactical aircraft production. The Army request totals $825.6 million, the Navy and Marine Corps figure is $783.3 million, with the Air Force getting the bulk of the funds—$1.586 billion.

DOD officials say the additional monies will provide for procurement of more than 2,000 helicopters and 900 fixed-wing aircraft. Of the aircraft to be purchased, the McDonnell F-4 will predominate, according to informed sources, accounting for virtually the entire Air Force request and for the bulk of the Navy request. The Navy will also get additional quantities of Grumman A-6A and Douglas A4E aircraft, CH-46A Sea Knight helicopters built by Boeing, and some funds for LTV's new A-7A attack aircraft.

Major items in the Army funding are the Boeing-built Chinook CH-47A and the Bell-produced Iroquois UH-1B helicopters.

The bill also includes $75.8 million for new tracked combat vehicles for the Army and $10.9 million for Marine Corps vehicles.

RDT&E funds included—In addition to new weapons, the supplemental also includes a request for more than $151 million in new research, development, test and evaluation (RDT&E) funds to accelerate a variety of limited war priority programs already under way and to begin some new ones. Defense officials list as examples of those which will receive additional suport: new night vision devices, new conventional ordnance, lightweight armor for helicopters, and communications equipment.

RDT&E funds by service break down as follows: Army—$28 million, Navy/Marine—$52.6 million, and Air Force—$71.1 million.

The total New Obligational Authority (NOA) requested of Congress in the supplemental is $12,760,719,000. Actual DOD funds account for $12,345,719,000, with an additional $415 million added to the bill for economic assistance, most of which is for Southeast Asia.

The measure also includes a separate supplemental request for $375 million, which does not require NOA, for military assistance to replenish DOD stocks drawn to support Vietnam. Officials point out that Section 301 of the defense authorization bill provides for merging these military assistance funds in regular DOD budget requests to avoid complications of separate financing and supply systems.

DOD officials say that of the $12.3-billion defense supplemental just submitted, the previous $1.7 billion supplemental passed last August and the $0.7 billion add-on for Vietnam passed in conjunction with the FY '65 budget, only $4.6 billion will actually be spent during FY '66. The remaining NOA is primarily for long-lead-time aircraft and helicopter programs.

Monies detailed—A breakdown of the total FY '66 supplemental, by functional classification, follows. The figures in parentheses indicate the amount that will actually be spent in FY '66.

Funds for additional military personnel, both active and reserve forces, total $1.6 billion ($1.1 billion). Operation and maintenance funds for all services and agencies total $2.3 billion ($1.9 billion), with the Army getting the biggest share. Procurement totals just over $7 billion ($1.3 billion), divided in this fashion: Aircraft—$3.15 billion ($360 million); missiles—$181 million ($33 million); tracked combat vehicles—$87 million ($9 million); ordnance, vehicles, and related items—$2.64 billion ($738 million); electronics and communications—$410 million ($45 million); and other procurement—$552 million ($123 million).

The total RDT&E figure of $152 million includes $5 million for military sciences ($1 million); $68 million for aircraft ($14 million); $9 million for missiles ($2 million); $12 million for ships ($1 million); $5 million for ordnance and vehicles ($1 million); and $53 million for what DOD calls "other equipment" ($12 million).

The enormous U.S. military construction build-up in Vietnam accounts for a supplemental request of $1.24 billion in the current bill. Some $260 million of this will actually be spent in FY '66.

Figures on the use of the $1.7 billion requested by President Johnson last August, which was incorporated as an amendment to the FY 1966 budget then passing through Congress, were also revealed by the White House. These included the information that $12 million was earmarked for missiles, $484 million for aircraft, $30 million for electronics and communications, $794 million for ordnance, vehicles and related equipment, $1 million for tracked combat vehicles, and $213 million for other procurement. There were no funds for military personnel, operation and maintenance and RDT&E, the remaining $166 million going to military construction.

Congressional action—Questioning on the supplemental request began immediately last week with a call for Secretary of Defense Robert S. McNamara to appear before a joint meeting of the Senate Armed Services Committee and the defense subcommittee of the Senate Appropriations Committee. Many members of these groups serve in both capacities, including the chairman and ranking majority member of both—Sens. Richard B. Russell (D-Ga.) and John Stennis (D-Miss.).

These groups are expected to continue their joint survey of the procurement and RDT&E portions of the bill, which amount to about $7 billion. These two categories require passage of authorizing legislation by the Armed Services Committees of the House and Senate.

The defense appropriations subcommittee will then continue with hearings on the remaining portions of the bill, including military personnel, construction, and operations and maintenance.

Plans for hearings by the House Armed Services Committee on procurement and RDT&E had not been firmed up late last week, although it had been decided not to hold joint hearings with the House Appropriations Committee after the fashion of the Senate.

The defense appropriations subcommittee is expected to try to hold hearings with the secretary this week. This subcommittee, which has an active minority group which has questioned McNamara tactics in the past, is expected to question the timing of the supplemental request, the bombing question, and other points.

One feeling growing on the Hill is that the large supplemental request, only $4.6 billion of which admittedly will be spent this year, was made in order to decrease the size of the regular FY 1967 budget, thus making it possible to arrive at a favorable deficit figure for the regular budget.

The supplemental request will delay the progress of special hearings scheduled by both the House and Senate Armed Services Committees (M/R, Jan. 17, p. 15), which in turn will delay the consideration of the FY 1967 budget itself.

The preparedness subcommittee of the Senate Armed Services Committee, chaired by Sen. Stennis, announced that it will hold hearings on a subject it has followed closely for quite some time, that of the logistics and supply system supporting the armed forces in South Vietnam. Member and staff reports were made in closed hearings last week. ■

Greater Oceanographic Effort Fostered by Senate Committee

by Heather M. David

THE SENATE Commerce Committee is expected to meet shortly to start action on legislation that would set up machinery for a coordinated national oceanographic effort.

While oceanographic bills were passed by both the House and Senate last year, no conference between the two bodies was called to resolve the differences between them. The Senate group, however, is expected to take this step in the near future.

Meanwhile, Rep. Joseph Karth (D-Minn.), in a speech before the National Space Club, said that he felt that the $140-million oceanographic budget, which is divided among 22 agencies, "does not seem to be consistent with our present capability and the potential benefits."

Faster growth urged—Karth labeled the present rate of growth of the composite budget—which is from 8 to 15% per year—"not fast enough," although he said the determination of a figure should be considered by either a council or a commission.

The Minnesota congressman, who is chairman of the space sciences and applications subcommittee of the House Space Committee, last summer was appointed to the Merchant Marines and Fisheries Committee and was assigned to a post on the oceanography subcommittee.

Karth called for establishment of a "wet NASA" as probably the best way of achieving a coordinated government effort in oceanography. He pointed out that the Senate bill proposes a council for oceanography to be headed by the Vice President somewhat like the Space Council, while the House bill does not.

However, both bills call for the establishment of a self-liquidating commission to recommend plans for a program to the President. Administration witnesses before the Congress have disagreed with the necessity of such moves, agreeing only that a coordination among agencies doing federally sponsored oceanographic work should be intensified.

One of the dangers of growing too rapidly, Karth said, is the fact that there are only about 3,000 professionals now working in the field, with 12 schools teaching 300 graduate students and turning out only 20 Ph.D.'s each year.

However, other disciplines will also be needed, he pointed out. He also suggested that efforts to step up the educational program could be taken in oceanography as they have been in space, with establishment of NASA-type facility grants for universities on an expanded scale. These should emphasize the interdisciplinary approach, he said.

Potential benefits—Karth forecast greater emphasis on fields such as oceanography to solve the problems of hunger and poverty, which he said must be met before general acceptance will be made of the enormous outlays for space programs such as manned expeditions to Mars or the moons of Jupiter and Saturn.

He also challenged contractors who made corporate investments in oceanography in the early 1960's and have become disenchanted at the lack of payoff. His advice: "Stick around for a while."

He cited as an example of the relationship between space and oceanography the fact that the Naval Oceanographic Office has undertaken coordination of applications of manned Earth orbital operations in the field of oceanography. He also voiced his intention to ask that unmanned operations, such as applications of NASA's *Advanced Technology Satellite*, be incorporated into the same kind of agreement.

Among the areas in which space know-how uniquely fits the aerospace field to tackle the problems of oceanography Karth listed: 1) reliability and efficiency requirements, 2) systems management experience, 3) structures and materials, 4) operation in a hostile environment outside the atmosphere, 5) instrumentation and sensors—especially in standardizing, 6) computer, guidance and power systems, and 7) vehicle design and construction.

Karth praised the companies he said had "grasped the point," including North American Aviation with its new ocean systems facility, Lockheed with its marine laboratory, Nortronics with its work on the Navy's Deep Submergence Systems Project, General Dynamics/Electric Boat Division's long experience, and the underseas division of Westinghouse, now building a new research and test facility. ■

Unmanned Planetary Missions Stressed

NAS's Space Science Board advocates shift in emphasis after manned lunar landing; Mars singled out for initial efforts

THE SPACE SCIENCE BOARD of the National Academy of Sciences has issued a report calling for emphasis on unmanned exploration of the planets after the U.S. manned lunar landing, with nearly equivalent expenditures for lunar and planetary programs in the 1970-85 period.

The report, prepared by a group of scientists working under Gordon J. F. MacDonald of the University of California, declared that unmanned exploration of Mars should have priority in the post-*Apollo* period. Secondary importance was assigned to more detailed investigations of the lunar surface and unmanned exploration of Venus.

In order of priority, the group also listed the exploration of other major planets, comets and asteroids, Mercury, Pluto and interplanetary dust.

The report is the result of a meeting of eminent U.S. scientists at Woods Hole, Mass., late last summer.

Voyager obstacle—Since that time, however, the space agency has already announced the deferment of its long-planned unmanned exploration of Mars with the *Voyager* spacecraft primarily because of budgetary limitations. The first flight in the program, originally scheduled for 1971, has now been delayed until 1973.

Instead, NASA has announced that it will launch a *Mariner* spacecraft on a Venus fly-by mission in 1967 and two fly-by missions to Mars in 1969 using an 800-lb. *Mariner*-type spacecraft.

The report recommends the incorporation of life-detection experiments in early Mars landers "even though they may have a low chance of success.

"In the event of severely limited payload capability, the emphasis on life detection may have to be increased in order to permit high-priority environmental measurements to be taken," it adds.

Regarding Mars, the report said the major scientific question to be answered is the possible existence of life there either now or in the past.

Other questions include whether the planet is geologically differentiated, as is Earth, into a core, mantle and crust; whether evidence exists of seismic, volcanic, or mountain-building activity; whether Mars has come from the same chemical crucible as Earth and what is the character of its atmospheric circulation.

Among the desirable observations of physical processes on the lunar surface, the report says that even a simple observation of how a handful of dust is picked up from the surface and allowed to fall back would be enlightening.

Venus and Jupiter—In discussing Venus, the report notes "the possibility that the planet has been too hastily rejected as a biological objective in earlier discussions" and suggests that radiation measurements that indicate a surface temperature too high to support life may derive from non-thermal sources, that far lower temperatures may exist at the summits of high mountain ranges, and that some form of life may have developed in suspension in the very dense Venusian atmosphere.

The scientists said they were in-

NASA Issues Apollo Applications RFP

THE SPACE AGENCY has asked 23 firms to submit bids for the systems definition of the *Apollo* Applications program by Feb. 21.

Two or more firms are to be selected for the nine-month study. Later one of the firms will be named prime contractor, with the role of integrating experiments into the modified Lunar Excursion Module of the *Apollo* spacecraft. That selection will probably not be made until early to mid-1967.

The RFP was issued by the Marshall Space Flight Center, which has been assigned field center responsibility for the program. The Manned Spacecraft Center is responsible for the integration of experiments into the spacecraft Command and Service Modules.

NAA integrator?—While no final decision has been made, it is expected that North American Aviation Space and Information Systems Div.—prime contractor for development of the Command and Service Modules—will be assigned contractor responsibility for integration of experiments into the two modules.

The RFP issued by Marshall also provides for the integration of experiments into the *Saturn* launch vehicle instrument unit and the S-IVB stage on both the *Saturn IB* and *Saturn V* launch vehicles.

The *Apollo* Applications program calls for using launch vehicles and spacecraft developed for the lunar landing program in order to expand orbital capability in space up to 45 days, lunar surface missions of 14 days and 28-day lunar orbit flights. With the appropriate number of rendezvous, the staytime in Earth orbit is expected to be extended up to as much as 145 days.

Studies outlined—The systems definition studies will include mission analysis, experimental equipment, installation and integration of equipment, specialized crew requirements, launch facility requirements, tracking and other support functions.

The following firms were asked to submit proposals initially: Aerojet-General Corp., Sacramento, Calif.; Avco Corp., Wilmington, Mass.; Bell Aerospace Corp., Buffalo, N.Y.; Bendix Corp., Ann Arbor, Mich.; Boeing Co., Seattle; Chrysler Corp., Detroit; Douglas Aircraft Co., Huntington Beach, Calif.; General Dynamics Corp., San Diego, Calif.; General Electric Co., Philadelphia; Goodyear Aerospace Co., Akron, Ohio; Honeywell, Inc., Minneapolis; Hughes Aircraft Co., Culver City, Calif.; International Business Machines, Owego, N.Y.; Ling-Temco-Vought, Inc., Dallas; Lockheed Aircraft Corp., Sunnyvale, Calif.; Martin Marietta Corp., Baltimore; McDonnell Aircraft Corp., St. Louis, Mo.; Northrop Corp., Hawthorne, Calif.; Republic Aviation Corp., Farmingdale, N.Y.; Raytheon Co., Waltham, Mass.; Sperry Rand Corp., Great Neck, N.Y.; TRW, Inc., Redondo Beach, Calif.; and Radio Corporation of America, Camden, N.J.

terested in Jupiter because its high gravity may have preserved on the surface a good sample of the primordial material of the planetary system.

Considerable interest is also centered on the Great Red Spot of Jupiter, a surface feature that has been observed since the 17th century.

The report said that it is significant that in the investigation of planetary systems of other stars, Jupiter-like objects are likely to be encountered first.

The report lists 20 scientific questions concerning the five outer planets and proposes almost 50 scientific investigations.

The present report is the first of three that will result from the study, promising objectives in space research organized by the Space Science Board at the request of NASA. Parts II and III, to be issued during the next few weeks, will take up four branches of astronomy and special topics in physics and geophysics, rocket and satellite research, university programs, physiology and medicine, biology, and man's role in space research.

General chairman of the study was Dr. George P. Woollard, director, Hawaii Institute of Geophysics, University of Hawaii. Dr. Harry H. Hess, professor of geology at Princeton University, serves as chairman of the Academy's Space Science Board.

Further recommendations—Other major recommendations included:

—The launching of an orbiting planetary observatory;

—Delivering a simple drop probe to resolve the question concerning the high surface temperature of Venus;

—Immediate development of a fine-pointing control for rocket guidance, accurate to 10 seconds of arc;

—Consideration of an enlargement of NASA deep-space communication capabilities beyond present plans.

To support the outlined scientific program, the group recommended:

—Increasing manpower and facilities available to lunar and planetary science programs;

—Development by NASA of a substantial program for observation of planets through ground-based telescopes;

—Early opportunities for highly experienced observational scientists to explore the lunar surface;

—Joint study by NASA's Office of Space Sciences and Applications and Office of Manned Space Flight of early use of *Saturn V* for planetary exploration, with special emphasis on a Martian capsule landing in the early 1970's;

—Increased attention by NASA to development of research and educational capabilities in theoretical sciences related to study of the solar system. ■

Sea-Launched Ballistic Missile Warning Net Development Set

THE AIR FORCE'S program to provide the U.S. with an interim early warning capability against sea-launched ballistic missiles (SLBM) moves into the major development phase next month when contractors begin modifying an existing Semi-Automatic Ground Environment (SAGE) air-defense radar to fulfill the SLBM warning role.

Modification of the radar, an AN/FPS-26 normally used as a height-finder in conjunction with the SAGE/Back-Up Interceptor Control System (BUIC) continental air defense network, will be done by Avco Corp.'s Electronics Div. in Cincinnati.

Last week, the Air Force was slated to officially turn over to Avco one of the FPS-26 radars from a SAGE site in Nacelle, Washington, one of several which had been ordered shut down by the Defense Dept. The radar will be dismantled and shipped to the Avco plant, where it will be modified and tested as the SLBM warning radar prototype.

Avco received a $10.5-million Air Force contract last month for modification work on this radar, and also for modification of six other FPS-26 units (pending successful prototype operation). These will make up the seven-station SLBM network. An additional award to Avco, probably slightly in excess of $2 million, is expected prior to program completion.

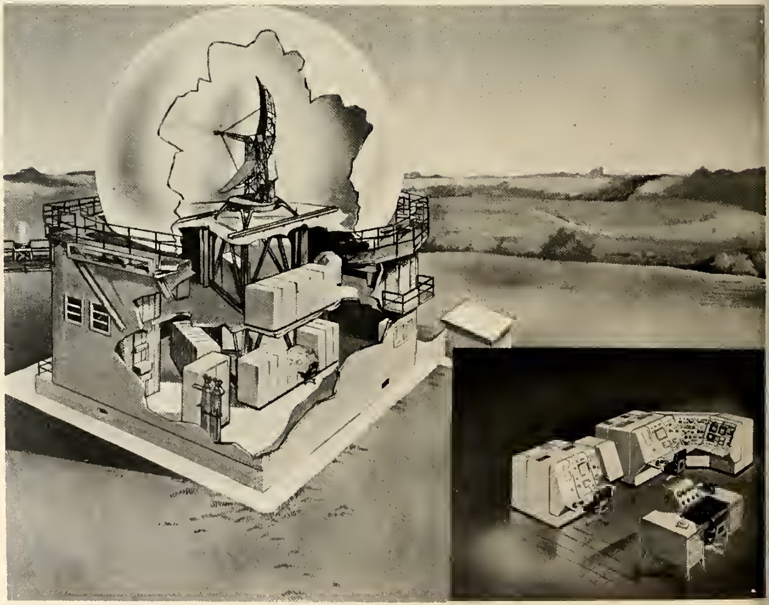
Selection of a contractor for the software, or programming, portion of the acquisition system is expected within the next few months.

Work on the SLBM warning network, known as 416N, is directed by the Air Force Electronic Systems Div., Bedford, Mass.

Seven-site network—When completed, the radar network will provide overlapping coverage around the Atlantic, Pacific, and Gulf Coast regions of the U.S. The seven sites include six existing SAGE complexes: Charleston AFS, Me.; Ft. Fisher, N.C.; MacDill AFB, Fla.; Mt. Laguna AFS, Calif.; Pt. Arena AFS, Calif.; and Mt. Hebo AFS, Ore. The seventh site will be a new complex built by the Air Force at Laredo, Tex. It will house the initial radar to be modified by Avco.

Air Force sources explain that the existing SAGE sites generally have two

Cutaway view of typical AN/FPS-26 radar installation in support of SAGE/BUIC network. Seven of these radars are being modified to meet the threat of SLBM's.



FPS-26 radars. Therefore modifications to one of them will not reduce the primary air defense role of the station. They also point out that the modified radars will be able to operate in either a SAGE or SLBM mode so that the system could be rapidly switched to provide two radars in support of any large air defense emergency.

The FPS-26, in either a SAGE or SLBM role, remains a line-of-sight (LOS) radar, subject to the basic physical limitations imposed on range by the radar horizon.

For aircraft detection, this translates into a maximum range of roughly 220 n. mi. against very high altitude targets. Against ballistic missiles, however, which climb considerably above the maximum altitude for aircraft, the radar horizon is greatly increased. Modifications being made to the FPS-26 reflect this.

Changes outlined—Major changes include a "slight" increase in transmitted power to achieve greater range (at least several hundred miles beyond the 220-n.-mi. figure), a decrease in the radar's pulse repetition frequency to compensate for the longer individual pulse travel time to and from the target, and a reshaping of the radar's antenna to reflect the changed gain and pattern requirements.

Modification of the initial SLBM radar is expected to take "close to a year," according to project sources. They also report that the follow-on hardware phase aimed at getting the entire system into operation "will move very rapidly."

The SLBM warning network is viewed as a tactical system with inputs fed into NORAD headquarters. The approach the Air Force has chosen for this first system is designed as "a quick and reasonably inexpensive" means for providing "at least a few minutes" of warning against ballistic missiles launched from submarines or surface vessels. It is not designed for use against shorter range, low-altitude, cruise-type missiles.

Looking ahead— Though Air Force planners say the 416N network will be effective against the present threat, they are most anxious to press into service new over-the-horizon radar methods "to meet the future threat."

For example, with LOS-limited radars pointed as close to the horizon as possible (with a 1-degree or less elevation to avoid sea return) a missile launched from 1,000 miles at sea would be roughly at 175 miles altitude before the radar could see it. While ballistic missiles can cover a 1,000-mi. range in roughly 14 minutes, more important to the evolution of warning time is that the launch phase of flight during the climb to altitude accounts for a large percentage of the missile's total flight time.

For this reason, the Air Force is looking to future use of over-the-horizon radars, in which radar energy is bounced off the ionosphere for one or more hops to regain the surface-to-radar horizon detection time lost with more conventional LOS radars.

Planners now tend to favor use of back-scatter receiver techniques, as opposed to forward-scatter, to provide virtually instantaneous launch detection. Officials say that a variety of over-the-horizon radars now in operation in connection with other Navy and Air Force projects show that the ionized gases characteristic of missile ignition and launch "provide an excellent radar return."

Planners see an SLBM warning system with very long range beyond-LOS capabilities as still about four years away. They point out that the very large costs of the individual radars is probably a bigger obstacle confronting deployment than is the technology. "The technical outlook is excellent for over-the-horizon radars," they report.

Project sources also feel that the R&D and operation of these radars carried on in other programs may eliminate the need for deployment of a model specifically for the SLBM task. ■

C-141 Used as Minuteman Transporter

The Military Airlift Command soon will be using its most modern transport, the C-141 Starlifter, to recycle the Minuteman missile from Strategic Air Command depots and bases. Initial flight testing of the Starlifter's suitability to transport the missile in its container, with a combined weight of 86,000 lbs., has been completed at Lockheed-Georgia Co., Marietta, Ga. Specifications for standard military payload call for 68,500 lbs. With the heavy missile in its container loaded aboard, a C-141 takes off for a test flight in which it flew at 470 mph and altitude of 20,000 ft. Planes, slightly modified to haul the missile, will be delivered to MAC late this month for operation while further testing continues.

U.S. AIR FORCE
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Manned Apollo Flight To Test Optics

Guidance official confident stars can be seen in daytime, but proof of capability must await launch later this year

by Jinx Mercer

HOUSTON—Whether astronauts will be able to find and identify proper navigation stars using *Apollo* optical equipment may remain an unresolved question until the first manned *Apollo* flight later this year.

A guidance and navigation specialist at the National Aeronautics and Space Administration's Manned Spacecraft Center here told MISSILES AND ROCKETS that one of the primary tasks onboard the first manned Earth-orbital *Apollo* flight will be to align the platform on the day side of the orbit.

"This will tell us if we really have a problem," he said.

Apollo navigation equipment relies on stars as a reference for aligning the vehicle's platform. However, *Mercury* and *Gemini* astronauts have reported being unable to find stars in the day side of the orbit (M/R Jan. 10, p. 17).

Visibility reaffirmed—Cline W. Frasier of MSC's guidance and control division declares, however, that the argument is "fairly conclusive" that stars can be seen in the daytime.

Although *Apollo* optical equipment has never been put to an operational test, similar instruments have been demonstrated by the Massachusetts Institute of Technology. (MIT has the overall responsibility for the design, development and integration of the *Apollo* guidance and navigation system into the Command and Lunar Excursion Modules.)

"MIT engineers have demonstrated this standing on building rooftops and using an instrument giving 28X magnification on a clear day." He said they were able to see stars of plus-three magnitude.

Apollo's optical navigation equipment consists of a 28X magnification sextant with a 1.8-degree field-of-view employing a 1.6-in-dia. objective lens, and a 1X scanning telescope to aid acquisition of stars with a 60 degree field-of-view and a 0.2-in.-dia. objective lens.

Identification crucial—Frasier emphasized that "seeing" stars was not the problem. "The question is whether the astronauts can acquire and identify proper navigation stars." The sextant, he said, has a very narrow field-of-view. Navigators must first seek out the constellation and then the location of a particular star.

This is further complicated in that light transmission through the telescope is reduced to 25%, diminishing brightness of stars by 1.5 magnitudes.

Theoretically, the 28X magnification of the sextant intensifies a point source 784 times. However, the exit pupil of the instrument is not advantageously matched to the entrance pupil of the eye and the instrument, therefore, loses 96% of its potential. Frasier said that transmission losses further reduce this theoretical value to a level of about one percent.

Proponents of the system are hoping the intensification produced through magnification by the sextant (about 2.5 star magnitudes) used in conjunction with the wider field-of-view of the scanning telescope will overcome this problem.

If no stars are visible through the telescope, Frasier suggested that a course alignment could be made on Earth-Moon-Venus or some other combination, followed by a rough optics alignment. The onboard computer can then be used to point the sextant to stars in order to refine the alignment. Celestial position coordinates for such non-inertial reference objects could be computed by the mission control center on the ground and called up to the crew for inserting into the spacecraft's onboard computer.

Saturn V Stage Goes Aloft

S-IC first stage of Saturn V is hoisted into Marshall Space Flight Center's new dynamic test stand. Initial tests will determine vibration and bending characteristics of booster only, but complete Saturn V-Apollo will be "shaken" later.

This may allow *Apollo* astronauts to use their platform "even in the worst case," he explained. "Until we actually fly a scanning telescope, we cannot say conclusively that we will not have problems with that instrument." Frasier pointed out that the scanning telescope and the sextant are externally protected by mechanically operated covers during the launch phase and other critical periods during the mission to keep the optics clean, and recessed within the Command Module to shield the optics from direct or reflected light.

The navigator, also, will operate the optical instruments in an area sheltered from light coming through the windows and will be better dark-adapted.

Studies continue—The G&C Div., Frasier added, has initiated several investigations that may help define the space environment as it exists on the day side of the orbit. One engineer is researching pilot reports for pertinent celestial observations; others are mapping out experiments that may bring in data before *Apollo* manned flights.

In general, G&C engineers hope to devise tests under controlled conditions to effectively tackle the problem. "Right now, we are trying to determine what is practical on *Gemini* spacecraft in view of the window limitations, particularly its deposits."

Astronauts may use the hand-held telescope carried onboard the *Gemini 7* spacecraft, or the Air Force sextant used during *Gemini 4* and *Gemini 6* experiments to sweep out a portion of the day sky in the search for stars.

The telescope has variable magnification (2-10X), and the sextant has 4.5X magnification and a field-of-view (13.5 degrees) that is appreciably larger than that encompassed by the sextant aboard *Apollo*. ■

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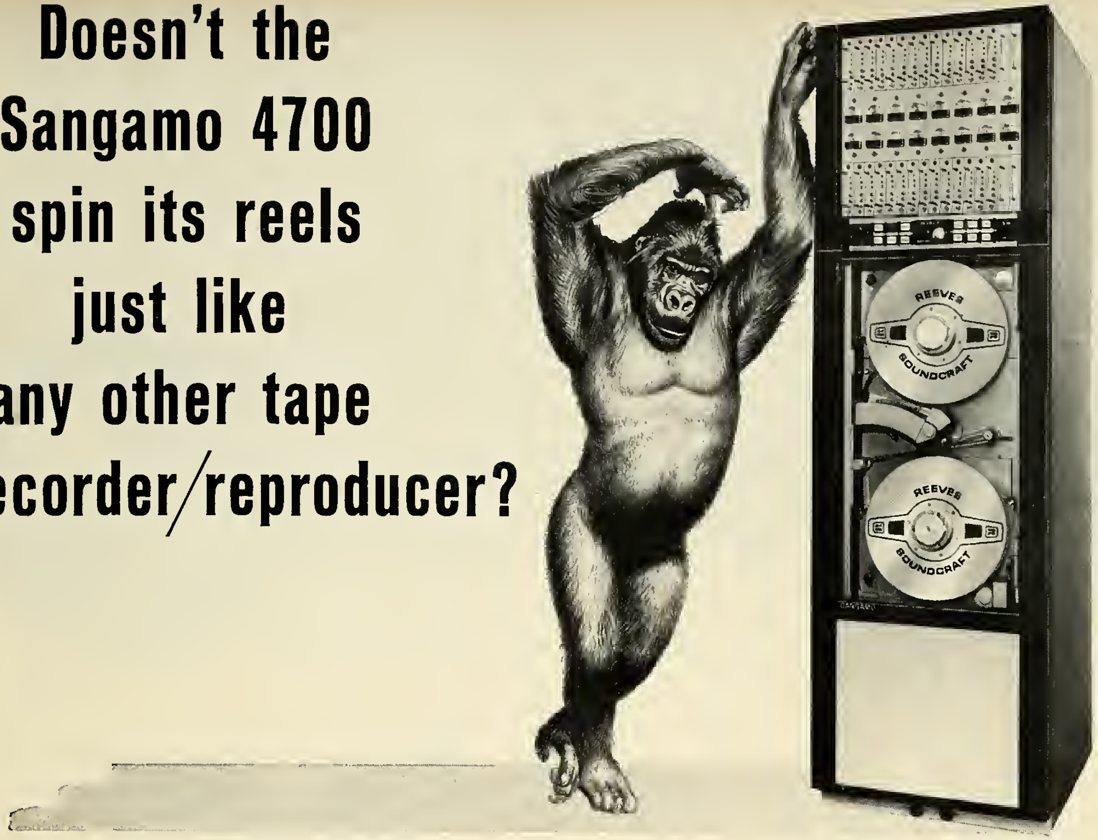

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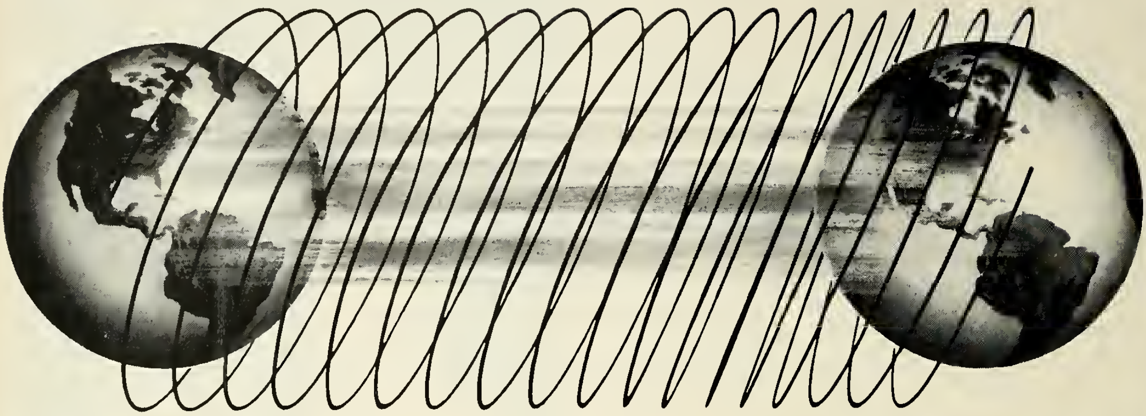

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Technical Countdown

ELECTRONICS

Dual UV Spectrograph for Aerobee 150

A gyro-stabilized dual spectograph with a pointing accuracy of ±15 arc seconds in one axis will be flown above the Earth's atmosphere by an *Aerobee 150* sounding rocket to take measurements in the spectrum between 1,200 and 3,000 Angstroms. Perkin-Elmer Corp. is building the instrument for the Kitt Peak National Observatory. During the 4-5 minute flight outside the atmosphere, the *Aerobee* controls its attitude to ±15 arc minutes. A spectral resolution of 1 Angstrom is expected.

Clear Air Turbulence Probed by Lasers

Use of lasers to detect clear air turbulence is reported by the University of Michigan. With a Q-switched ruby laser and optical radar receiver manufactured by Lear Siegler Inc., sufficient evidence of an ability to detect turbulence and particulate discontinuities was found to provide the basis for continuing experiments. These are being carried out under the direction of Dr. Peter A. Franken, who reports "We have in mind the possibility that turbulent regions could provide a bunching or 'blotchiness' of particulate matter that might have a merely layered structure in calm atmospheres." He added "The present flight program could not distinguish these . . . because . . . our optical radar only provided a one-dimensional exploration of the atmosphere forward of the aircraft." The experiments are scheduled to continue soon with a new type of laser now under development by Lear Siegler. This is expected to provide the type of two-dimensional forward map required. Research will be carried out in jetstream and mountain-wave air currents and in severe storm-associated turbulence, at altitudes up to 30,000 ft.

ASTRONAUTICS

Indirect Ascent Best for Mariner '69

For the 1969 *Mariner* Mars mission, the *Atlas-Centaur* will provide maximum payload weight if it flies in the indirect ascent mode. This is the opposite to predictions for the 1967 mission with the same vehicle. Studies by Tim J. Kreiter at NASA/Lewis show that use of a parking orbit and *Centaur* second burn puts a 1,635-lb. payload into a Type I trajectory. A 60-minute launch window and a 30-day launch interval is allowed for. Direct ascent with only one burn would give a 1,330-lb. payload. Flight time would be 21 to 45 days longer than with indirect ascent, and communications distances at encounter would be as much as 0.28 au greater. For Type II trajectories, indirect ascent gives a payload of 1,930 lbs., compared with 1,700 lbs. for direct ascent.

1971 Mars-Earth-Return Mission Studied

Continued analyses of Earth-Mars-Earth round trips show that of the 1969, 1971, 1973, and 1975 opportunities, the one in 1971 has particular advantage. P. H. Feitis of Jet Propulsion Laboratory reports that the 1970-71 launch opportunity is remarkable in requiring a velocity increment at Mars of only 0.03 km per second for a sunlit-side pass and a 30-day launch window. Photo interpretation experts have urged that video-data quantities that only trajectories such as this can bring are essential before Mars surface experimentation is carried out (M&R, Feb. 22, 1965, p. 39). The 1970-71 Earth-return mission would pass Mars at an altitude of 180 km and would have a total flight time of about 578 days. Preliminary analysis shows that the communication distance from such a probe would always be smaller than that of a Mars orbiter. The Earth-return probe would transmit 1.5 times as much data after the first 100 days following encounter than the best orbiter, said Feitis. This ratio would increase steadily as the mission continued. During the final two-day Earth encounter, the probe would transmit 600 to 40,000 times the amount transmitted by a 200-day orbiter, depending on the aiming distance.

LIFE SUPPORT

Battelle Studies Life-Support Systems

Closed-cycle life-support systems should be attainable within two decades, Dr. John Foster of Battelle Memorial Institute's Columbus Laboratories concludes. Foster calculates that 22 lbs. of life-support materials will be needed per astronaut, about 85% of which would be composed of water requirements, recycled through various evaporative processes. About one to one-third pound of water-free food substances will support one astronaut. While most of the food suply on initial long-term space trips will have to be dehydrated concentrates that can be reconstituted with a renewable supply of water, Battelle is studying higher plants, such as the sweet potato, that offer promise. Hydrogenomenas bacteria also have potential as carbon dioxide converters and food sources, Foster said. Battelle also is investigating chemical systems for converting carbon dioxide into solid carbon and gaseous oxygen, including the Bosch and Sabatier reaction cycles.

MATERIALS

Strip Silicon Promising for Solar Panels

By producing silicon in the form of half-inch strips up to 18 ft. long, Westinghouse Seminconductor Division hopes to provide a means for doubling the power output of solar panels. The strips will greatly reduce the number of electrical connections needed on panels. Westinghouse has a $249,995 contract from the Air Force Aero Propulsion Laboratory at Wright-Patterson AFB to further develop the strip-silicon production method and to deliver a quantity of solar cell strips for fabrication into panels.

SPACE SUPPORT

Million-Pound Deadweight Machine Readied

Nineteen 50,000-lbs. weights have been produced by United States Steel Corp. for a million-pound deadweight testing machine. Accurate to within eight ounces, the stainless steel weights will enable the calibration of load cells and proving rings used to measure rocket engine thrusts. When combined with a 50,000-lb. frame, the weights make up the largest deadweight machine ever built. The unit is 96 ft. high and is installed in a pit lined with stainless steel. Each weight is a forging 10 ft. in diameter and between 10$\frac{15}{16}$ in. and 15$\frac{3}{16}$ in. high.

Apollo Ship, Aircraft Elements Readied

Five vessels, eight planes being modified for lunar mission tracking function under contracts totaling $137 million

by Sue Butler

Cape Kennedy—The air and sea armada that will support Project *Apollo* is gradually taking shape.

Last July, the Air Force activated an *Apollo* Task Force (Ships). Its five instrumentation-laden *Apollo* ships are now in various stages of modification expected to cost a total of $110 million.

Eight Air Force C-135 aircraft slated to serve as *Apollo* Range Instrumented Aircraft (ARIA) will be modified and instrumented under a $27-million contract awarded in October to a Douglas/Bendix team.

The ships and planes will be dispersed around the globe to keep tab on all crucial phases of the *Apollo* lunar mission save the landing itself.

They will track the *Saturn V-Apollo* liftoff from launch complex 39 at the Kennedy Space Center; follow the rocket through separation of its three stages, including the critical period of Max Q (maximum aerodynamic pressure); be in touch with the *Apollo* pilots when the spacecraft is inserted into Earth orbit; and follow it through up to three revolutions, until it is injected into its lunar trajectory.

After a brief stay in port and on base, the ships and aircraft will again take up assigned stations in order to monitor and provide communication links with the *Apollo* Command Module during the final phases of its return to Earth, including re-entry.

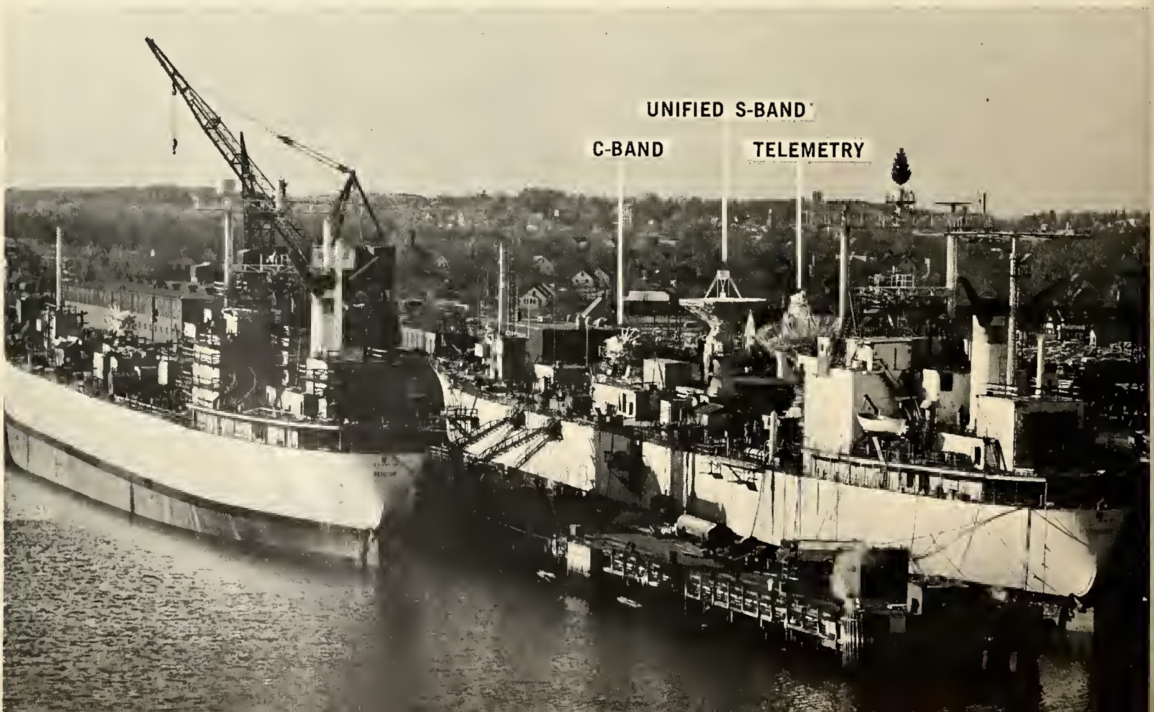
Veteran ships—The waterborne segment of the support force will consist of two venerable TAGM's (Navy terminology for auxiliary general missile ships) and three modified Navy T-2 tankers.

The Huntsville and Watertown are instrumentation ships from the Western Test Range and belong to the "6" class. They are 455 ft. long, with 62-ft. beam, 23-ft. draft and 12,000-ton displacement. Currently undergoing conversion at New Orleans' Avondale Shipyard by Ling-Temco-Vought, they will be on duty in the Pacific, over which re-entry is scheduled to occur, and are therefore designated "*Apollo* re-entry ships."

The trio of converted oilers, all World War II veterans, consists of the Vanguard, Redstone and Mercury and belongs to the "19" class. Displacing 22,300 tons each and measuring 595 ft. in length, with 75-ft. beam and 25-ft. draft, they will be "the largest tracking ships in the world . . . as far as we know," according to Lt. Col. George K. Patterson, who heads the *Apollo* Task Force (Ships).

New look—Their conversion, being performed by General Dynamics/Electronics at the firm's Electric Boat Shipyard at Quincy, Mass., is giving the vessels new silhouettes. Each ship's

Apollo tracking ships USNS Redstone, left, and USNS Vanguard being outfitted at Quincy, Mass., shipyards of General Dynamics Corp. The 595-ft. tankers are being modified under terms of a $110-million contract from the Navy's Bureau of Ships.



middle section, about 300 ft. long, is being cut out and replaced by a longer and wider section increasing overall length by 73 ft. Bows and sterns will be retained, along with propulsion units.

Vanguard and Mercury are being "jumbo-ized" through a gradual buildup of their mid-bodies while the Redstone, in a different drydock, is having its tanker section floated out and midbody prefabricated; the latter will be floated in for faster assembly.

The contract for all five instrumentation ships is being coordinated through ISPO—the Navy Bureau of Ships' Instrumentation Ship Project Office.

The Vanguard, aptly named because she will indeed be the vanguard of the other instrumentation ships, had her "float out" on Sept. 7 and is slated to arrive at the Eastern Test Range's Port Canaveral for testing and support by July 1. She will begin supporting *Apollo* flights starting with *Saturn IB* No. 203, the third launch scheduled in the *Saturn IB* program.

During *Saturn V-Apollo* missions, she will be positioned about 1,000 mi. southeast of Bermuda in the Atlantic as "*Apollo* insertion ship" to monitor and track the spacecraft during insertion into the Earth-orbit phase.

Most of the Vanguard's delicate electronic equipment is already installed and undergoing integration and checkout.

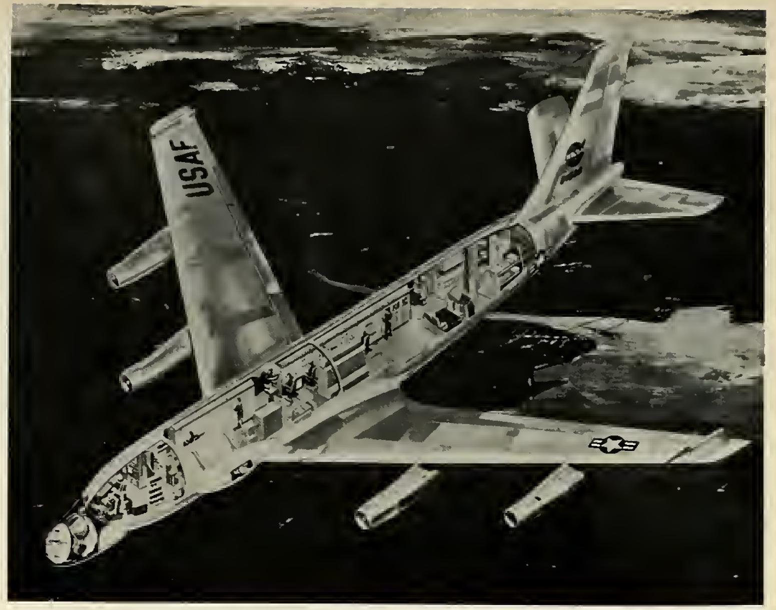
One of her sister ships, the Redstone, came out of drydock on Dec. 7; the second Mercury, is scheduled to float out on Feb. 12. Tentative target date for declaring them operational is Oct. 1, 1966 for Redstone and Jan. 1, 1967, for Mercury. Both will serve as "*Apollo* injection ships" (injection into the lunar ascent phase), the Redstone in the Pacific and the Mercury in the Indian Ocean.

These "19" class ships will each carry 11 major systems in support of Project *Apollo*, including three never before carried aboard instrumentation vessels.

New Systems—The innovations:

—Unified S-Band, 2,200-2,300 megacycles, furnished by NASA. A 30-ft. parabolic antenna used with the S-band provides spacecraft beacon tracking to 367,000 n.mi.; range/rate velocity accurate to 0.07 meters per second; communications to and from the spacecraft, including voice, command control, data link with command and control systems, telemetry, television and biomedical data.

—The latest and refined model of SINS (Ship's Inertial Navigation System), incorporated in SPAMS (Ship Position and Attitude Measurement System). In addition, SPAMS includes a marine star tracker, a bathymetric navigation system, a LORAN (Long Range Navigation System), and a "Flexure" monitor subsystem that measures the twist of the ship and assists in correcting antenna angles using a laser beam.



Cutaway view of Air Force JC-135 aircraft as modified for Apollo tracking duty by Douglas/Bendix team. Four of eight such planes will carry advanced camera systems.

—A NASA Mission Control Center, a miniature of the Houston Manned Spacecraft Center facility. The control center, capable of telemetry readouts and voice communication, will have a 10-man complement and be part of the Goddard Space Flight Network.

And old—The eight other systems aboard consist of:

—C-band radar on the 5,400-5,900 megacycle band, with parabolic antenna and system identical to the FPS-16 widely used on the ETR;

—Broadband telemetry spanning the 215-2,300 megacycle range, requiring a 30-ft.-dia. dish;

—High-frequency, very-high-frequency, ultra-high-frequency and voice communication systems. (HF usable within several thousand feet, VHF and UHF dependent on line of sight.)

—Central Data Processing System (CDPS), a digital computer system whose heart is a Univac 642B modified computer. Col. Patterson said the CDPS aboard the three ships will be "similar" but differ in some minor aspects;

—Command Control System, provided by NASA for *Apollo* support, including four quad-helix antennas;

—Operations Control Center (Air Force), the nerve center of the ship itself and tied in with the ETR's range safety office;

—Timing system providing all standard timing formats, such as DOD's IRIG (Inter Range Instrumentation Group) code, the NASA code and the UT2 (Universal Time) code;

—An acquisition and stabilization network that links all the instrumentation aboard ship. (It tracks the information relayed by HF from shore to ship, consolidates it with the ship's position; and is used to point the tracking antennas at the spacecraft and stabilizes them against motion.)

200 aboard— Each ship will have living facilities for nearly 200 persons—80 will be RCA scientists and technicians, 10 will be from Pan American World Airways' Guided Missile Range Division, 10 will be NASA personnel and the balance will be the vessel's operating crew.

The "6" class converted oilers will have essentially the same capabilities as the "19" class ships except for a smaller S-band parabolic antenna (a dish of only 12-ft. dia.), and lack of a floating NASA mission control center. Personnel aboard will be reduced accordingly.

Air coverage—To bolster this surface armada of limited mobility, the Air Force is acquiring eight four-jet JC-135 aircraft, the military and instrumented version of the Boeing 707.

Flying at 450 knots (about 517 m.p.h.), the aircraft are expected to make up in speed what they might lack in on-board equipment, such as radar.

The planes, still flying MATS (Military Air Transport Service) missions out of McGuire AFB, N.J., are all of 1961 vintage but handpicked for their good condition.

The first is due to be delivered to Douglas' Tulsa, Okla., plant for modification early this year, and three are to be ready in March, 1967.

Priority calls for all the aircraft to be in use 30 days out of each quarter for *Apollo* mission support. At other times they will be available to fly general range-support missions.

Four of the planes are expected to be equipped with ALOTS, the new Airborne Optical Tracking System designed to provide high-quality photographs of spacecraft and launch vehicles throughout early launch, staging and re-entry regardless of weather conditions (M/R, Nov. 22, p. 26).

The other four aircraft will be modified to accept ALOTS so that any combination of craft will be able to support *Apollo* missions. Turn-around time for switching ALOTS pods to other modified aircraft will be 48 hours, according to Lt. Col. Donald Farris, maintenance chief for the 6550th Air Base Group at Patrick AFB, Fla.

A ninth C-135 bearing an ALOTS prototype and delivered to the ETR in November will also be available on a standby basis, said Lt. Col. Arval C. Norsworthy, chief of the Group's Air Operations Support Branch, Operations and Training Division. ARIA is under the jurisdiction of the division headed by Col. James C. Petersen.

All the aircraft will have telemetry recording and receiving equipment, voice relay capability, and certain beacons for calibration and frequency checkout.

Improvements—Col. Norsworthy pointed out one of the principal advantages of the instrumented C-135's over the C-130's currently in use: the current model has only VHF frequencies while the JC-135 will have S-band and therefore better opportunity and wider range to acquire data on tape.

Another improvement over existing instrumentation is new timing equipment which will record in "near" real time and provide for clearer signals. The equipment will have improved receivers, recorders and a higher-gain antenna, a 7-ft. parabolic dish mounted on the aircraft's nose and capable of turning—35 degrees down and 70-90 degrees in horizontal plane out of axis. The C-130's are still equipped with relatively crude 1958 equipment, including a smaller helical antenna.

The system could be expanded to include both L-band and X-band.

He referred to "near" real time because there will not be direct retransmittal. "Selected portions of the re-entry, for instance, will be relayed by teletype to Houston and the Cape within five or 10 minutes," he explained. "VHF signals will be received from the spacecraft, data read off manually, and transmitted to ship or ground station by HF."

The JC-135's will have increased VHF and UHF transmission range because they will be flying at 40,000 ft. and "see" over the horizon. The modifications will permit voice communication with the spacecraft both during insertion into orbit and while in Earth orbit, strengthen communication during the transfer to the lunar ellipse, and assure direct communication during re-entry.

Need for the latter was pointed up during Scott Carpenter's *MA-7* flight May 24, 1962, when he overshot the impact area by some 250 miles and was temporarily "lost" at sea.

The C-135's further will be able to "dump" data to a ground station. In the instrumented C-130's, data can be accepted but not retransmitted.

Better cameras—During the interview with M/R, it was revealed that ALOTS' cameras may be uprated by the time the system is operational. The present 200-in. focal-length telescope may be modified to 400 in., doubling distance or accuracy. "There is lots of modification potential," one of the briefers said pointedly, but he declined to discuss further ALOTS changes that may be contemplated.

The aircraft will not have metric capability. Their radar will be limited to navigation and weather. However, a study program is presently under way at the Air Force Systems Command's Electronic Systems Division at Hanscom Field, Mass., on airborne instrumentation platform that would have metric capability, too. A possible modification of an IFLOT (Instrumented Focal Length Optical Tracking) system with an 80-in. focal length now adapted for the rear of C-54's is being investigated.

C-135 was handy—The aircraft that is being eyed for broader use, including metric capability, is the JC-141, instrumented military equivalent of Lockheed's Starlifter. Some Air Force experts believe it could perform virtually all the functions now limited to ocean-going vessels.

However, key to selection of the C-135's was availability, Col. Norsworthy indicated.

Each aircraft will have a Douglas flight crew of four and an additional operating crew of at least seven men.

The precise deployment of the ARIA is still not determined but it appears that from three to six aircraft will be used for the critical lunar injection phase. Fewer aircraft will be required for other mission phases, Air Force project officers speculated.

While being organized by DOD and NASA specifically for Project *Apollo*, ARIA will also be available for AAP (*Apollo* Applications Program) and be adaptable to the Air Force's own *Manned Orbiting Laboratory* (*MOL*) program. ■

Steady Demand Expected for Jindivik Drone

EXPERTS at Australia's Government Aircraft Factory believe that the *Jindivik* target drone might continue in production for another 20 years.

Reusability is one of the reasons for these hopeful predictions for this target for testing guided weapons. *Jindivik*—an aboriginal word meaning "the hunted one"—today has a life expectancy of 50 flights, apart from missions on which shoot-downs are called for.

The aircraft has acquired many refinements since the first models were built. Performance of the currently operational Mark 3A version greatly outstrips that of ancestral types. The drone soars at high subsonic speeds (about Mach 0.86) at altitudes from 100 to 65,000 ft.

Jindivik is said to be one of the oldest aircraft types still in production. The Government Aircraft Factory in Victoria has delivered 289 for use in Australia, Britain, Sweden and the U.S., and there are sufficient orders on the books to keep the production line open for several more years.

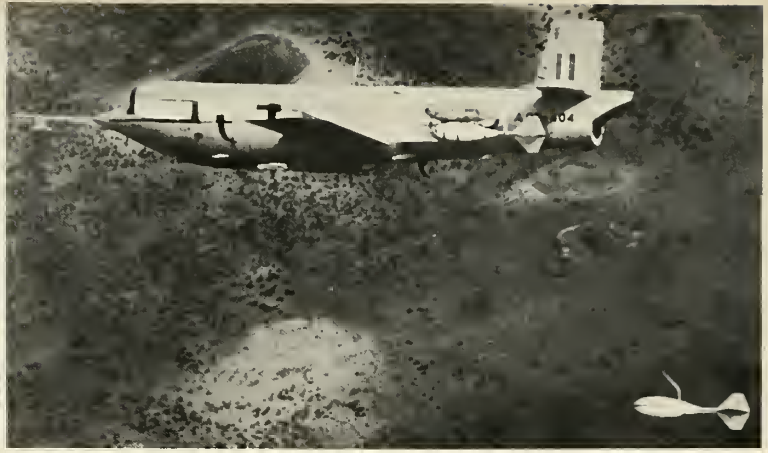
The system is operated by LTV Aerospace Corp. for the U.S. Navy as a target for surface-to-air and air-to-air missiles on the Pacific Missile Range.

Sustained production experience with *Jindivik* has made a healthy contribution to Australian aviation technology. The *Malkara* anti-tank missile, adopted by the British Army, was designed and built at the Government Aircraft Factory and the factory is now building Mirage III jet aircraft for the Royal Australian Air Force.

History—After World War II, the Australian and British governments signed a joint agreement under which the Woomera Rocket Range and its supporting facilities were established to test guided weapons. The program required a pilotless target plane, and the job of designing, developing and manufacturing it went to the Government Aircraft Factory.

A piloted version of the craft—called the Pika—flew for the first time in November, 1950. Only two were built, and the 214 flights they made until 1954 were to prove the basic *Jindivik* design

Right: Jindivik releases a target, which will trail out behind it on a wire. Below left: remotely controlled landings are monitored on a screen that looks like this one. Below right: Royal Australian Air Force pilot and navigator control Jindivik flight from ground station during missile trials at the Woomera range in South Australia. The drone can be used up to 50 times, and takes off and lands much like a conventional aircraft does. It is powered by a 2,500-lb.-thrust turbojet engine.



and its guidance and control systems.

The work was handled by a team led by the factory's chief designer, Ian Fleming, now controller of aircraft and guided weapons for the Department of Supply, the federal government department responsible for the Government Aircraft Factory.

Other aspects of the program have been shared by the department's Aeronautical Research Laboratories and the Weapons Research Establishment at Salisbury, in South Australia, as well as by the British companies that have supplied components.

Mark 3A is powered by a Bristol Siddeley Viper ASVII turbojet of 2,500 lbs. thrust. The wing span is 25 ft., 7.2 in., and the aircraft is 23 ft., 3.75 in. long.

Jindivik is usually controlled from a ground station, although the job can also be carried out from a "shepherd" aircraft.

Operation—The main items of control equipment are a radio control receiver, units for interpreting external signals, automatic pilot, and a telemetry transmitter for passing essential control information back to ground. Much of this equipment is supplied by British firms.

Normally, remotely controlled targets are launched from an aircraft and recovered by parachute. This leads to heavy loss and damage. *Jindivik* has the distinction of being able to take off and land intact almost like a conventional aircraft.

Jindivik's originators estimated its life expectancy at about five flights only. But successive improvements have greatly extended this to about 50.

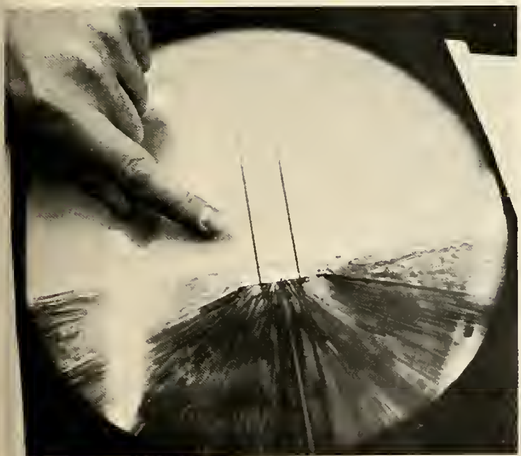
Only rarely does a weapons trial call for the aircraft to be shot down. Generally, the weapon is directed to "miss" at a predetermined distance from the aircraft. The weapon's performance can be checked by the range instrumentation and through the instruments carried in *Jindivik*.

The optical instruments include Australian-designed cameras fitted with ultra-wide-angle lenses. The cameras are mounted in pods on each wing and are used to film the approach and proximity of missiles fired against the aircraft. Without significant loss of performance, *Jindivik* can also tow a small target on wire that can be streamed thousands of feet from the aircraft.

Jindivik takes off on a normal airstrip under its own engine thrust. For takeoff, the aircraft is mounted on a three-wheeled trolley, the nose wheel of which is steerable. When the aircraft reaches takeoff speed, it is automatically released from the trolley. *Jindivik* lands on a simple, retractable skid.

Jindivik's main use has been at Woomera, where highly organized procedures have been developed to enable several large weapons trial programs to take place simultaneously against a relatively small number of target aircraft. *Jindivik* can be adapted to perform a variety of missions in these trials.

Small crew—A relatively small ground crew can control the flight: the skipper, who pilots the aircraft once it is airborne, and a navigator, who tracks the flight pattern. Neither of these sees *Jindivik* in flight, and the takeoff and landing are controlled by a



pilot and a batsman on the airstrip when the aircraft is in visual range.

At Woomera, extremely precise formation flying has been carried out with flights of three *Jindiviks*, their wingtips only 50 ft. apart.

Only the prototype version of *Jindivik* had the advantage of manned test flight. Despite this, few aircraft have had their performance so fully monitored. As *Jindivik* is a trials aircraft, each flight is recorded by range instrumentation.

Another source of flight information is the analog computer at the Government Aircraft Factory, which is used to simulate many flight situations. Thus the design is constantly under inspection both in the field and in the laboratory.

Apart from 133 *Jindiviks* delivered for use in the joint British-Australia weapons program at Woomera, 122 have been delivered for use in Britain, 24 to the U.S. and 10 to Sweden. Further *Jindiviks* are on order for the joint project, for Britain and the U.S.

Jindivik sells at about $112,000 (ex Australia). The aircraft's high recovery rate makes it attractive economically.

Various roles other than as a target have been considered for *Jindivik*. For instance, it has possibilities as a high-altitude surveillance aircraft, or as a weapon launched from a ship or aircraft to carry a warhead beneath enemy radar cover. ■

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space biology

Procedures for Lunar Surface Sampling Outlined by Scientists

DETAILED RECOMMENDATIONS by the scientific community on the handling of lunar surface material acquired in the *Apollo* and *Apollo* Applications programs are disclosed by NASA in the proceedings of a conference published recently.

The recommendations deal both with procedures to yield the best scientific data from the experiments and to guard against the contamination of lunar samples by Earth organisms. Among the specific ideas:

—Examination of samples by conventional means such as mass spectrometry, capillary gas chromatography, spectrophotometry, electron probe and other physical methods.

—Microbiological studies such as the introduction of lunar materials to animals or plants stressed by physical, surgical, chemical or radiation means to see how they react.

—Studies of influence of lunar material on bacteriological transformation, by exposing genetic material (DNA) to lunar material before absorption by recipient cells.

—Strict control of astronaut activities to prevent contamination of the samples.

—Construction of a lunar sample receiving laboratory in which strict quarantine can be enforced while scientific investigation is under way.

How to identify—The biosciences group, chaired by Dr. Melvin Calvin of the Universtiy of California, was one of a number of scientific disciplines represented at the Conference on Lunar Exploration and Science held at Falmouth, Mass.

Although the Moon has generally been regarded as dead in terms of its ability to support biological forms, the scientists emphasized the importance of discovery of any organic compounds that would help answer questions relating to the origin and history of the Moon, to the relationship of the Moon to the Earth and to the universe.

Since the questions they would like answered include whether life on the Moon exists, ever did exist or could develop, the kinds of investigations will be broad and general and on a molecular level rather than by culture techniques or yes-no life-detection devices.

Very sensitive techniques must be used, the working group pointed out. For instance, discovery of components with carboxyl and amino groups would not suffice per se; it would be necessary to determine whether the compound were one of the usual amino acids to conclude that it could have originated from the same primordial sea as Earth forms.

The state of the art in structure determination is reaching the level of sophistication required for these tasks, the group concluded, with mass spectrometry, in combination with other techniques such as ultraviolet spectroscopy, UV-fluorescence and infrared spectroscopy, evolving as the method of choice.

The group suggested other analyses in addition, and comparisons of the compounds found on the Moon with those encountered in geological formations of various eras in the Earth's history, such as early Precambrian sediments and others.

Although the Moon probably lacks a solvent system for the support of life, the scientists point out, the probable conditions of low temperature, high vacuum and low radiation that might exist in subsurface protected areas can be regarded as favorable for freeze-drying preservation. Upon exposure to the proper environment, should these exist, lunar material might be made to exhibit the true characteristics of a living entity.

Exhaustive attempts to isolate and culture "micro-life" systems by inoculating culture media, tissue cultures, embryonated eggs, and plant and animal hosts also should be done, the scientists said. In addition to introducing material to "stressed" animals, the scientists suggested that pregnant animals also could be used, since the fetus is often unusually susceptible to infectious or toxic agents.

No contamination—The group was intensely concerned with the problems of achieving samples of the lunar surface without the possibility of their being immediately contaminated with Earth life forms transported by the *Apollo* crew.

The scientists pointed out that microbial contamination of the lunar samples could result in considerable difficulty during the quarantine process, especially if the astronaut-contributed contaminant happens to be a pathogen such as hemolytic streptococci.

Chemical contamination could result in considerable confusion and erroneous conclusions regarding the history of the Moon or the presence of life.

The Lunar Excursion Module itself presents a potential source of contamination through the venting of the atmosphere and equipment that is moved down from the LEM to the lunar surface, the scientists pointed out.

The bioscences group recommended that the LEM atmosphere be vented through an ultra-high-efficiency biological filter before the exit of the astronauts, and that all equipment and apparatus to be moved to the lunar surface be sterilized while on Earth with ethylene oxide or heat.

The sterile sampling tool and lunar sample containers could be encased in a thin film of Teflon to maintain them in sterile condition, the scientists suggested. Teflon, the group concluded, is the only plastic known to be acceptable to the organic chemists although more study is necessary to determine its ability to withstand the environment. Outer rigid sample containers may be made of stainless steel or of Inconel, and closed in the lunar vacuum for the return. Inner containers should be made of a Teflon-metal laminate able to achieve a vacuum, the group recommended.

The scientists also suggested that a lunar sample enclosed aseptically might be left for permanent storage on the lunar surface to assure at least a small portion of the crust that would not be contaminated.

Astronaut suit problem—Outgassing of the astronauts' suits on the Moon's surface is a problem that warrants study, the group said. Biological leakage tests to determine the amount of microbial and organic contamination and the extent of the area around the astronauts that might be contaminated was cited as the subject of an immediate study.

The group also urged immediate initiation of a feasibility and design study leading to the development of a manually actuated lunar sample collection tool for acquiring organically and biologically clean surface and near-surface samples.

Training for the astronauts in collection techniques, which would assure aseptic and chemically clean samples, also was recommended.

The third possible source of trouble the group found was in contamination from burning of the LEM rocket fuel. The biosciences group called for a study of the trace organic impurities in the fuel as well as the detailed combustion products that might be formed, in order that they not be confused with indigenous lunar surface compounds.

Further review of the problem of radiation sources on the *Apollo* spacecraft also was urged to assure that no radiation degradation of the returned sample could be possible.

The group also detailed design recommendations for the lunar sample receiving laboratory, which it said should be a double barrier system. The first barrier would consist of a series of gas-tight chambers and cabinets in which the sample would be kept at all times. The secondary barrier would be the laboratory itself, with such precautionary features as incineration and filtration devices to handle all effluents from the building, and negative air pressure to prevent outgassing. ■

No Static Firing Scheduled For Gemini 8 Agena Target

by Robert Lindsey

SUNNYVALE, CALIF.—A crash program to modify and re-qualify the *Gemini-Agena* target vehicle (*GATV*) ended here last week. Wind tunnel tests on the vehicle are to begin late next month and continue into March.

The re-configured *Agena* for the *Gemini 8* rendezvous and docking mission was shipped to Cape Kennedy ahead of schedule. The wind-tunnel tests will be done at Arnold Engineering Development Center, Tullahoma, Tenn.

Despite criticism following failure of the *GATV* in the abortive Oct. 25 *Gemini 6* mission, Lockheed Missiles & Space Co. has elected again not to static-test the vehicle before flight.

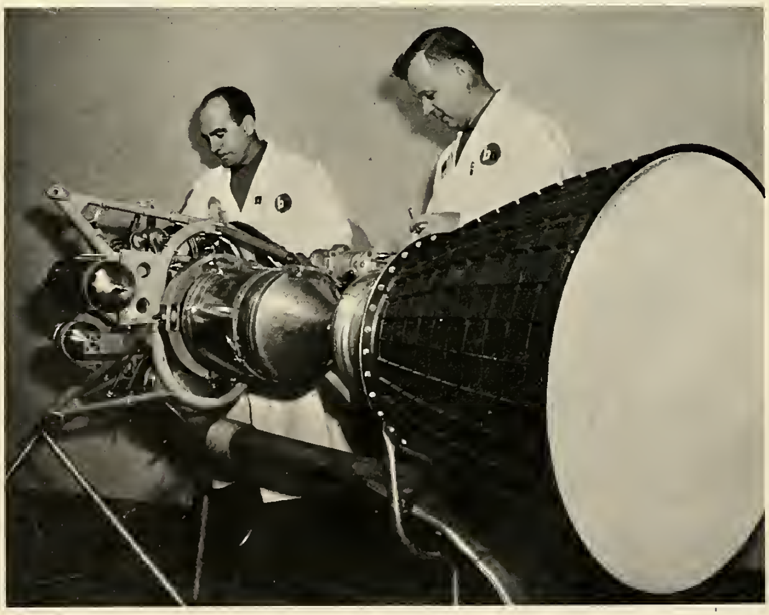
LMSC, the Air Force and NASA were sharply criticized by some segments of the press after the October failure for not testing what was essentially a new vehicle before entrusting it to an important manned mission.

Jack Shoenhair, LMSC-NASA *Agena* program manager, said firing the redesigned vehicle was considered, but it was decided the tests would not increase reliability of the system, and might degrade it. Shoenhair said Lockheed's position is that failure to static fire the *Gemini 6* target vehicle "had nothing to do with the failure experience." As with the *GT-6 Agena,* he said, the *Gemini 8 GATV* engine has been tested intensively.

Some high-placed NASA officials, MISSILES AND ROCKETS learned, are unhappy with the decision not to test the entire stage, but Lockheed is backed by the Air Force and Aerospace Corp.

Delivery of the *Gemini 8 GATV*—No. 5003—culminated the Sunnyvale aspects of an intensive exercise in engineering detective work to learn what caused the *GT-6* mission failure and a 7 day-week, 24 hour-a-day program

Unexpected reaction between fuel and oxidizer in this Agena engine used in the GTA-6 mission Oct. 25 caused "hard start" of engine and resultant Agena failure.



called "Sure Fire" to redesign the *GATV*. The work was done by LMSC under a supplement to its cost-plus-incentive-fee contract. Other aspects of the program are already under way at AEDC and at Bell Aerosystems, Wheatfield, N.Y., manufacturer of the *Agena* engine.

In spite of the program, LMSC officials said, the company will meet its original schedule for delivery of the *Gemini 8* target vehicle, in fact beat the schedule by about three days. They said the vehicle will meet all performance requirements and the modifications will have no effect on the *GATV's* restart capabilities. Five restarts are guaranteed and LMSC believes between 10 and 15 are possible.

Modification questioned—Ironically, LMSC believes the Oct. 25 failure was caused by a modification of the basic *Agena* engine designed to increase its reliability.

The blame is placed on a "hard start" of the engine, caused by introducing the fuel (unsymmetrical dimethyl hydrazine) into the combustion chamber before the oxidizer (red fuming nitric acid).

In the standard *Agena* Engine 8096 configuration, oxidizer enters the combustion chamber about 50 millisec. before the fuel.

But the sequence was reversed in the multi-restart *GATV* to slightly decrease oxidizer consumption; to permit faster start and shutdown of the engine; and basically simplify the start system so it had maximum reliability.

Shoenhair said Lockheed failure analysis teams examined scores of possible causes for the mission failure and invited authorities from other industries, universities, NASA and the Air Force to a symposium to track down the reason for the mysterious failure. "We've been very careful not to feel we had any absolute answers," he noted.

Among the main possible causes scrutinized were several kinds of electrical malfunctions; a secondary propulsion system failure affecting primary propulsion; electrical power failure to the engine; damage to the stage by shrapnel following separation; propellant valve failure; and turbine overspeed causing engine shutdown. All were rejected for various reasons.

LMSC feels the cause was an unpredicted reaction between the oxidizer and fuel. It believes about two pounds of fuel had gathered in the combustion chamber, as planned, before the oxidizer entered the chamber. When the hypergolic propellants came in contact, the theory holds, a small and unexpected explosion occurred, causing a shock wave that severed several wires.

This caused automatic shutdown of the engine, as the fuel tanks were being pressurized. Since no fuel was leaving the tanks, the pressure caused the tanks to rupture. Initial tank pressurization is 58 psi; Lockheed believes the tank could withstand up to 100 psi before rupturing.

The engine as before—To eliminate the hard start problem, LMSC is reverting to the 8096 configuration using an oxidizer lead.

The principal modification is addition of an oxidizer manifold pressure switch (OMPS) and a positive control relay.

(There is one interesting historical sidelight to the problem. According to Lockheed sources, failure of an *Agena* in one of the initial *Ranger* missions was traced to the engine not starting its second burn because the OMPS failed because of heat feedback. When the *Gemini-Agena* program was started, NASA decided to take the switch out of the system to increase reliability.)

Besides returning the OMPS to the system, Lockheed is also making minor changes in the electrical harness for the start system, on the possibility the failure might have been caused by electrical malfunction. Another small change in the *GATV* is a revised telemetry return rate to provide better understanding of the events in the engine ignition.

Concurrent testing—While LMSC has been conducting its failure analysis program, re-configuration and re-qualification of the *GATV* here, it has been working with the Air Force and Bell Aerosystems on two other fronts. Bell is testing the new engine configuration in sea-level tests involving at least 40 starts and 1,000 seconds of operation.

At AEDC, top priority is assigned to the *Agena* over other programs, including testing of the engine for the Lunar Excursion Module.

Ignition and performance of the reconfigured *GATV* engine is being tested at simulated altitudes of 250,000 feet and above. At this point, Shoenhair noted, the Tullahoma tests are the pacing factor in the total re-qualification of the "new" *Agena.*

Tests should continue through March and will probably conclude with an attempt to recreate the events of Oct. 25, with a fuel lead into the combustion chamber. This test is being delayed until the end because of the possibility it could damage the AEDC test cell.

Concurrent with the "Sure Fire" failure analysis program, Shoenhair noted, Lockheed has established a second task force to suggest possible improvements in the *GATV*. "This is a completely independent team that we told to make a design review of the whole vehicle. They are new people who are taking a completely fresh look to make recommendations for possible changes in future vehicles." ■

advanced materials

MSFC Testing Beryllium for Structural Use

ENDURANCE TESTS are being conducted at the Marshall Space Flight Center on an eight-foot beryllium beam. Beryllium is expected to become an important structural metal for the space program.

NASA is interested in the metal because it is only one-fourth as heavy as steel, yet retains exceptional rigidity and is extremely strong. It is already used in smaller rocket components to curb weight of the rocket and thus add vital pounds to the payload it delivers into space.

The fabricated beryllium beam is believed to be the largest beryllium sheet metal structure in existence. Despite its eight-foot length, it weighs only 22 lbs. It will be used to study beryllium fabrication processes, assembly methods, and to define design problems for aerospace structures.

Tests conducted on the beam—which was made by the Berylco Company—will be geared to learn the deflection characteristics of beryllium structures and their modes of failure, such as buckling and fracturing.

Josef F. Blumrich, chief of the Structural Engineering Branch, Propulsion and Vehicle Engineering Laboratory at MSFC, said problems exist in forming beryllium at this time because it requires special equipment and technology and because it has poor ductility and deformation characteristics. Progress has been made, however, in rolling, forging and extrusion. He added that joining is still a difficult process.

For example, plug soldering has been used to attach reinforcements because mechanical fasteners such as rivets have presented problems because of associated cracking. Extensive research is now under way on joining beryllium components with adhesives. Some bolts have already been used in joining after a cushion of epoxy adhesive was used between the beam and steel fittings.

Blumrich says the beryllium beam could withstand a load of about 10 tons at each of the two steel fittings before it failed. ■

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Douglas researchers look into the eyeball of a pigeon to improve the weather eye of a satellite.

This intriguing research project at Douglas deals with analysis and electronic simulation of a pigeon's eye to learn how optical information is processed. One application is a super realistic radar for satellites and interplanetary craft. The ultimate goal is to develop an advanced computer technology from a knowledge of the biological computer—the brain. This program is typical of Douglas research capability, which involves hundreds of projects and embraces virtually every branch of science. **DOUGLAS** **gets things done**

MISSILE AND SPACE SYSTEMS GROUP

The Industry Week

Mergers and Acquisitions

Ling-Temco-Vought, Inc., Dallas, has acquired the assets of The Okonite Co., Passaic, N.J., for approximately $30 million. The firm manufactures high-voltage cable and will be operated as a wholly owned subsidiary of LTV. . . . *Stockholders of Vapor Corp., Chicago, and American Meter Co., Philadelphia, have approved a merger of the two firms. The new firm will be called Amercon Corp.* . . . California Computer Products, Inc., Anaheim, Calif., is acquiring Data-Plot Associates, Inc. Data-Plot has been sales representative for the California firm in the Washington, D.C., area for several years. CCP manufactures digital plotters and plotting equipment. . . . *Robinson Technical Products, Inc., Teterboro, N.J., plans to purchase the assets of Cal-Val Research and Development Corp., Burbank, Calif. The move is part of an expansion program for the firm's Vibrashock Div.*

International

United Aircraft Corp., East Hartford, Conn., Leesona Corp., Warwick, R.I., and Energy Conversion, Ltd., London, have agreed to extend their joint development program and licensing agreement relating to development and manufacture of fuel cells. When approved by the State Dept., the agreement will extend the existing program to 1984. . . . *Raytheon Europe International Co. has established an office in Paris. Harold M. Landau will head the office, which represents Raytheon's Missile Systems, Space and Information Systems, Equipment, and Submarine Signal Divs.* . . . Osaka Bearing Manufacturing Co., Ltd., Osaka, Japan has named American Koyo Corp., Cleveland, to market Osaka bearings in the U.S. and Canada. . . . *Leeds & Northrup Co., Philadelphia, has established Leeds & Northrup Australia Pty., Ltd., to manufacture, sell and service electronic instruments and automatic controls in Australia.*

New Activities

Litton Industries, Inc., Beverly Hills, Calif., is considering the feasibility of constructing a shipbuilding facility at Lorain, Ohio, on Lake Erie. A definite decision will be reached after full-scale development studies taking several months, company officials said. . . . *Hercules Powder Co. plans to increase production facilities for Herculon olefin fibers by 25%. This will boost capacity to more than 50 million lbs. annually. Expansion of the Covington, Va., plant is expected to be completed by the end of this year.* . . . Consolidated Electrodynamics Corp., Pasadena, Calif., has set up a Data Instruments Div. combining all its data-processing operations. Harry S. Black has been named general manager of the new division. . . . *Xerox Corp., New York City, has reorganized its Washington, D.C., marketing functions into a single government branch.*

Facility Expansions

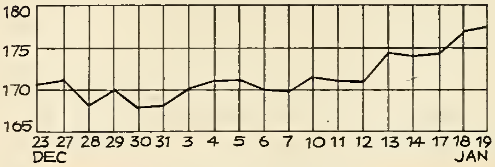
Allis-Chalmers plans to build a 32,000-sq.-ft. fuel cell laboratory in Greendale, Wis. The building will be used for engineering and test of power systems for NASA. . . . *Lead International, Inc., a recruiting firm for scientific, engineering and administrative personnel, has completed construction of new facilities at the Denver Technological Center, Denver, Colo.*

Potpourri

The federal government has given approval for design and construction of a $55-million atom smasher at the Los Alamos National Laboratory, N.M. More than $1 million authorized by Congress for the program last year was released recently by the Bureau of the Budget. It has been reported that the Administration has approved further funding for the proton accelerator in the new budget. . . . *Curtiss-Wright Corp., New York City, has been tendered about 4,118,000 shares of its common stock under an offer to purchase 1,000,000 shares at $32 per share. The company said it will accept 1 million of the shares on a pro-rata basis of about 24% of those tendered. The offer was made Dec. 15 and expired Jan. 14.* . . . The aerospace industry and labor unions clashed again last week. About 3,600 members of the International Assn. of Machinists struck Bendix Corp.'s Kansas City plant Jan. 17 after rejecting the firm's current three-year contract proposal. Economic provisions were the main issue, a union spokesman said. In Fort Worth, Tex., the IAM local voted to strike General Dynamics Corp. on Jan. 22 if a new contract was not signed. Issues there were "non-economic" and involved policies and split working weeks, the union said.

Missile/Space Stock Index

The President's State of the Union message outlining his intention to keep the U.S. in Vietnam and release of the $58.3-billion DOD budget and the $12.3-million DOD supplemental produced additional activity in defense stocks during the past two weeks. In addition, rumors that either Pan American World Airways or Trans World Airlines is considering ordering fleets of jet aircraft from Boeing or Douglas accounted for activity in those stocks.



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
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No matter how skilled and imaginative you may be, your professional progress will continue to depend upon the challenge and technological status of your assignments. As you may have seen reported in general news and scientific journals, Hamilton Standard is setting a fast pace on many fronts: Space Life Support, Propulsion Systems, Environmental Control Systems, Engine Controls/Special Controls, Electron Beam Technology, Electronics, Ground Support Equipment. Representative positions:

DESIGN ENGINEERS—for advanced spacecraft components and systems involving atmosphere revitalization, fluid and heat transport, water management and reclamation of oxygen and water from waste products. Sound working knowledge of thermodynamics, fluid mechanics and mechanics is required. Duties will include trade-off studies for life support systems, creation of optimum schematics and systems and components design.

SENIOR EXPERIMENTAL ENGINEERS—to undertake varied assignments on mechanical systems involving heat exchangers, rotating machinery, hydraulic and/or pneumatic equipment. Should have experience in devising and conducting environmental tests for structural and performance evaluation, and preparing component specifications for tests, manufacture and procurement. Requires knowledge of thermodynamics, heat transfer and/or hydraulics, pneumatics and electricity.

AERODYNAMICISTS—to work on the aerodynamic design and performance prediction of aircraft propellers and fans and marine propellers. Must have a sound background in incompressible and compressible aerodynamics. Preferably with an understanding of propeller and fan theory, airfoil theory and aircraft performance evaluation. Assignments would include performance analysis, method development involving both steady and unsteady aerodynamics, and the investigation of the effect of aircraft components on propulsor design and performance. BSAE or MSAE required.

ANALYTICAL ENGINEERS—with experience that has emphasized analytical studies in thermodynamics and heat transfer. Familiarity with environmental system concept, analysis and trade-off studies. Knowledge of turbine, fan, compressor, and heat exchanger design and test analysis.

TEST EQUIPMENT ENGINEERS—to conduct test development programs from proposal to final development stage. Will be responsible for producing a wide variety of mechanical equipment involving hydraulic systems—hypergolic/cryogenic fuel handling systems. Products would include mobile or stationary test facilities and equipment applicable to the aircraft and aerospace industries.

ELECTRONICS DESIGN ENGINEER—Experience in discreet type or digital controls design. Oriented in both analytical and hardware phases of design activity involved in closed loop digital control systems. Product applications involve jet fuel controls, synchrophasers, cabin pressure controls and similar aircraft or aerospace closed loop systems. Requires BSEE or MSEE preferred.

SENIOR EXPERIMENTAL ENGINEER—Electronics—BSEE. Should have experience in R&D testing of electronic control systems involving circuit or system design and/or transistor analog-digital circuit design. To plan, conduct and evaluate product development programs in field of electronic systems applicable to stabilization and navigation equipment, aircraft and missile flight controls, aircraft and rocket engine controls and other related systems.

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contracts

AIR FORCE

$11,200,000—**General Electric Co.**, New York City, for continued research and development work on the Mark 12 space re-entry system in Philadelphia.

$4,000,000—**United Aircraft Corp.**, East Hartford, Conn., initial increment to a $13-million contract for development work on a vectored thrust cruise propulsion system.

$3,000,000—**Lockheed Aircraft Corp.**, Sunnyvale, Calif., to continue production of *Agena* boosters.

$2,900,000—**Aerojet-General Corp.**, Sacramento, Calif., for production of components for the *Titan III* rocket system.

$1,283,000—**Raytheon Co.**, Bedford, Mass., increment to previous contract for work on a rocket research program.

$1,253,000—**Hughes Aircraft Co.**, Culver City, Calif., fixed-price contract for work on an air-to-surface missile guidance program.

$907,611—**Garrett Corp.**, AiResearch Manufacturing Co., Phoenix, Ariz., for experimental research and development work on SNAP 50/SPUR mechanical power unit concept.

$501,290—**Clark Equipment Co.**, Clark Development Div., Cassopolis, Mich., for development of a transport/handling system for 156-in.-dia. solid rocket motors.

$366,430—**Whittaker Corp.**, Marmo Research and Development Div., San Diego, Calif., for development of large high-temperature sandwich structures.

$150,000—**Sylvania Electric Products, Inc.**, Hicksville, N.Y., to develop a high-temperature coating to protect future spacecraft.

$149,988—**Ohio State University**, Research Foundation, Columbus, Ohio, for research on transmission of intense laser radiation.

$100,000—**University of Illinois**, Urbana, Ill., for broadband and millimeter antenna techniques.

$95,315—**Raytheon Co.**, Space and Information Systems Div., Sudbury, Mass., for measurement and filtering techniques for optimal orbit navigation.

$83,000—**Thiokol Chemical Corp.**, Reaction Motors Div., Denville, N.J., for research on elastomeric and compliant materials resistant to liquid rocket propellants.

$76,761—**North American Aviation**, Rocketdyne Div., Canoga Park, Calif., for spare parts for the *Atlas* propulsion subsystem in support of the *Abres/Nike Zeus* program.

$64,416—**Space General Corp.**, El Monte, Calif., for *Nike-Iroquois* rocket hardware.

$50,000—**Litton Systems**, Applied Science Div., St. Paul, Minn., for research and investigation of depth of penetration of bombarding ions into the sputtered surface.

$50,000—**Stanford Research Institute**, Menlo Park, Calif., for research and development on infrared modulator utilizing free carrier absorption for CO_2 laser.

$47,209—**General Dynamics Corp.**, Electronics Div., Rochester, N.Y., for investigation of radiation transfer processes and coherent optical interactions in ruby lasers.

ARMY

$41,093,332—**Martin Marietta Corp.**, Orlando, Fla., for research and development work on improved support equipment for the *Pershing* missile missile system.

$6,285,181—**Global Associates**, Oakland, Calif., for base logistics support at the missile test center at Kwajalein Island.

$5,792,714—**Day & Zimmerman, Inc.**, Philadelphia, to manufacture 60-mm. rockets in Texarkana, Tex.

$1,550,000—**American Electronic Laboratories**, Colmar, Pa., for electronic equipment.

$451,695—**Thiokol Chemical Corp.**, Redstone Research Div., Huntsville, Ala., six-month contract for test and evaluation program on sustainer motor cases.

$288,634—**Consolidated Electrodynamics**, Huntsville, Ala., for magnetic tape recorder/reproducer system to be located at Kwajalein Island test site.

$160,750—**Avco Corp.**, Research and Advanced Development Div., Wilmington, Mass., for R&D effort for discrimination studies for the *Nike-X* missile system.

$68,500—**Astro Space Laboratories**, Huntsville, Ala., for design of multi-rail launcher and fabrication of prototype component parts.

$49,573—**Hydraulic Research Manufacturing Co.**, Burbank, Calif., for repair parts for *Hawk* missile system.

$29,400—**General Electric Co.**, Missile and Space Div., Philadelphia, increase in contract for additional effort for design, fabrication and check-out of an extended dynamic range orthicon TV system, Project Glow.

$28,822—**United Transformer Corp.**, New York City, for *Hawk* missile system transformer repair parts.

$27,351—**Syracuse University Research Institute**, Syracuse, N.Y., for one-year study of the stability of spherical shell subject to time-dependent loads.

NAVY

$33,329,034—**Norris-Thermador Corp.**, Los Angeles, for manufacture of components of 2.75-in. rockets.

$23,824,805—**Lockheed Aircraft Corp.**, Sunnyvale, Calif., for research and development on submarine-launched missiles.

$18,588,205—**Goodyear Aerospace Corp.**, Akron, Ohio, to manufacture *Subroc* missiles.

$13,095,638—**Sylvania Electric Products Corp.**, New York City, for classified electronics equipment in Mountain View, Calif.

$6,777,122—**Alcan Aluminum Corp.**, Riverside, Calif., fixed-price contract for rocket motors for 5-in. *Zuni* rockets.

$6,542,619—**Norris Thermador Corp.**, Vernon, Calif., fixed-price contract for rocket motors for 5-in. *Zuni* rockets.

$3,507,837—**Raytheon Co.**, Bedford, Mass., for an advanced development model of anti-submarine warfare radar.
$782,000—**Sanders Associates**, Nashua, N.H., to design and develop anti-submarine warfare sonobuoy system.
$441,000—**Varo, Inc.**, Garland, Tex., for the manufacture of static power inverters to be used aboard *Polaris*-type submarines.

NASA

$815,000—**Doan Electric Co.**, Cleveland, from Lewis Research Center for instrumentation, data acquisition and controls systems for the space propulsion facility at Plum Station, Sandusky, Ohio.
$682,374—**United Aircraft Corp.**, Research Laboratories, East Hartford, Conn., from Headquarters for experimental research on gaseous nuclear rocket technology.
$637,500—**TRW, Inc.**, Systems Group, Redondo Beach, Calif., from Goddard Space Flight Center to fabricate plasma wave detection experiments and associated equipment for the *Orbiting Geophysical Observatory* program, Mission E.
$627,347—**Avco Corp.**, Research and Advanced Development Div., Wilmington, Mass., from Lewis Research Center for design, development, fabrication, test and delivery of electrothermal engine systems.
$492,000—**Burns & Roe, Inc.**, New York City, from Lewis Research Center for design of expansion of propulsion systems laboratory for supersonic facility and preparation of plans, specifications and cost estimate.
$280,000—**General Dynamics**, San Diego, Calif., from Goddard Space Flight Center for flight dynamics computer program for the *Apollo* insertion ship.
$94,086—**Booz-Allen Applied Research, Inc.**, Bethesda, Md., from Marshall Space Flight Center for ADP system study.
$94,000—**Dynatech Corp.**, Cambridge, Mass., from Marshall Space Flight Center for research and design of a practical and economical dielectrophoretic system for the control of liquid fuels under low gravity environmental conditions.
$93,685—**GCA Corp.**, GCA Technology Div., Bedford, Mass., from Headquarters for investigation of performance of langmuir probes in the ironosphere.
$70,000—**Rodana Research Corp.**, Bethesda, Md., from Manned Spacecraft Center for *Apollo* emergency medical kits.
$63,900—**TRW Systems, Inc.**, Redondo Beach, Calif., from Headquarters for study of the solar wind, the magnetosphere and the transition region.
$58,471—**Interstate General Contractors**, Chicago, from Goddard for construction of operations building, antenna foundation road site grading and other services at Rosman data acquisition facility, Rosman, N.C.
$57,963—**Bell Aerosystems Co.**, Buffalo, N.Y., from Flight Research Center for study on modification of a lunar landing research vehicle to a lunar landing training vehicle.

INDUSTRY

$2,000,000—**Thiokol Chemical Corp.**, Elkton, Md., from **Hughes Aircraft Co.**, Culver City, Calif., for design and production of the main retro rocket for the latest scientific-payload version of the *Surveyor* lunar spacecraft.
$1,355,000—**Lear Siegler, Inc.**, Instrument Div., Grand Rapids, Mich., from **McDonnell Aircraft Co.**, St. Louis, Mo., to provide aerospace ground equipment for the F4C aircraft.
$280,000—**Planning Research Corp.**, Los Angeles, Calif., from **Lockheed Missiles and Space Co.**, Sunnyvale, Calif., for re-entry systems analysis.

MISCELLANEOUS

$99,000—**Perkin-Elmer Corp.**, Norwalk, Conn., from the **Kitt Peak National Observatory**, Tucson, Ariz., to build an ultraviolet astronomy spectrograph to be carried into space via high-altitude rocket probe.
Hughes Aircraft Co., Culver City, Calif., from the Swiss government for a modern tactical air weapons system to provide Switzerland with an electronic network of early warning and military defense control. Amount not disclosed.

Series 2201 for airborne applications. 1" diameter. Less than 3" long. Weighs less than 3.50 ounces. Hysteresis error less than 0.05% FSO. End point non-linearity less than 0.1% FSO. Wide operating temperature range from —100°F to +300°F.

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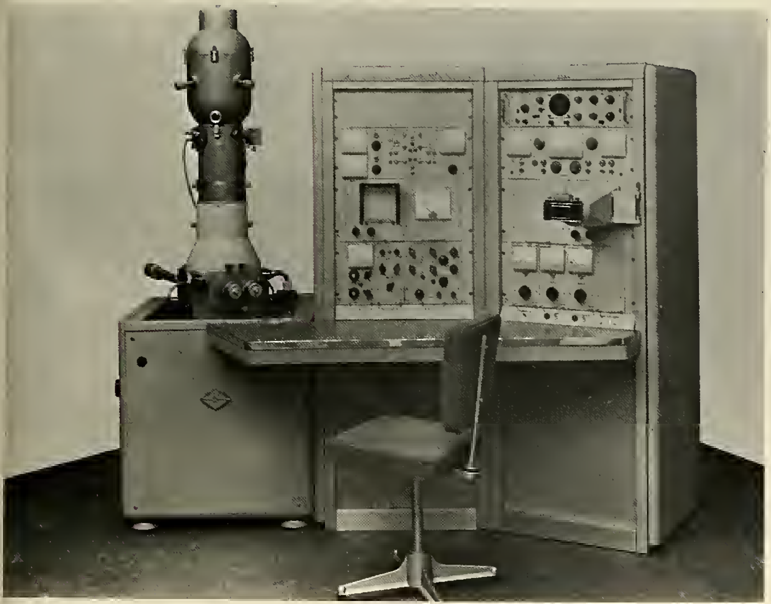

New Product of the Week:

Scanning Electron Microscope

A scanning electron microscope designed to examine specimens with complex shapes or uneven surfaces down to details as small as 200 Angstroms has been developed by Cambridge Instrument Co., Ltd.

Depth of focus is 300 times greater than that of an optical microscope set for the same magnification, according to the firm. The "Stereoscan" microscope throws images onto a cathode ray tube. It is designed to provide a maximum consistent resolution of 500 Angstroms or better and 200 Angstroms under favorable conditions. It has a magnification range from 50X to 20,000X corresponding to scanned areas of 2 mm. to 5 microns square.

The instrument directs a primary beam of electrons from a heated tungsten filament to a fine point on the specimen. The beam scans the surface by means of scanning coils and associated circuits. Secondary electrons are emitted from the specimen as a result of excitation by the primary beam. These are collected by a scintillation counter. The amplified output of the counter modulates the brightness of a CRT screen, scanned in synchronism with the electron-probe scanning the specimen.

Circle No. 151 on Subscriber Service Card

VSWR Meter

Microlab/FXR has announced the availability of a completely-transistorized, high-performance VSWR meter.

Model 813T measures wide ranges of VSWR, reflection coefficients, relative attenuation, and bolometer current. It can be used for audio frequency null measurements with an external bridge.

Sensitivity of the unit is 0.1 mv for full scale at 40 cps bandwidth with noise 5 db below input signal level. Selector switch permits choice of 20, 40, or 400 cps bandwidths for optimum operation; a range switch covers 70 db in 5 db steps. A variety of input conditions is provided to permit use with crystals or bolometers. Both recorder and a-c outputs are incorporated.

Circle No. 152 on Subscriber Service Card

Dual Camera System

Photomechanisms, Inc., has developed a "quick look" Polaroid Kine camera system, designed to photograph a dual display consisting of a 2 x 2-in. kinescope image and a 1.3 x 11-in. data identification display.

Both displays are recorded simultaneously by an optical system that includes two camera lenses to image the displays within a 2 x 2½-in. format at the camera's film plane.

Designed to photograph ground-displayed TV pictures of cloud cover transmitted from the *Nimbus* weather satellite, the camera simultaneously records alpha numeric mission identification data. These hard copy prints show the size, type, density and movement of clouds. The system has a vernier focusing arrangement that permits precise focus of the recording lenses.

The dual camera system is intended for checking the data setup and for standby use. It is interchangeable with other photomechanism equipment designed for continuous recording and processing of displayed data.

Circle No. 153 on Subscriber Service Card

Bridge Signal Conditioner

A low-noise transducer signal conditioner for strain-sensitive resistance transducers or load cells using shunt calibration is available from ELCOR.

The Model BSC-016C can be utilized as a single or in any number up to eight units in a rack-mounted housing. Output of the conditioner's isolated power supply is 0-16v dc and 0-64 ma. The unit is equipped with current-limiting short circuit protection.

Other specifications include a ripple of 100 mw and component resolution from 0.013 to 0.04%. Temperature coefficients run from 10 to 20 ppm/°C.

Circle No. 154 on Subscriber Service Card

Post-Detection Combiner

An optimal-ratio post-detection combiner, the Model 12S2, has been developed by General Electronic Laboratories, Inc.

The two-channel unit is capable of producing a signal-to-noise ratio exceeding that provided by the two associated receivers, the firm says. Frequency range is 5 cps to 1.5 mc. Signal-to-noise ratio improvements of 2.5 db can be achieved for equal inputs. An overall gain of 6 db minimum is obtained with an output level of 4v, peak-to-peak, into 75 ohms.

Circle No. 155 on Subscriber Service Card

Pressure Gauge

A new helical bourdon tube pressure gauge measuring 0.56 in. in diameter has been announced by American-Standard Advanced Technology Div. Designed especially for use on the *Mariner* space-

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craft, it is also adaptable for use in laboratories, industry, military, and aircraft programs.

The gauge features helical coil, direct-drive operation for high resistance to extreme shock and vibration and for extensive re-cycling capacity. The pointer is attached directly to the pressure coil for high accuracy, long life and low maintenance cost.

The unit meets all MIL requirements for temperature, altitude, vibration and shock. The vibration test includes 100 g's vertical, horizontal and front and back. Other specifications include a collar diameter of 0.78 in., overall length of 1.69 in., and stainless steel case. The dial reads from 0 to 300 psi.

Circle No. 156 on Subscriber Service Card

Casting Ceramic

A high alumina casting ceramic for use with temperatures up to 1,600°C is available from Aremco Products, Inc.

Ceramacast 505 is a 96% fine-grain alumina ceramic requiring no heat to set. The material combines good dielectric strength with high thermal conductivity and low thermal expansion rate (1.4 x 10^{-7} in./in./degree F, the firm says. Shrinkage is 0.2% volumetrically after curing. The material resists oils, solvents and all acids except hydrofluoric.

Circle No. 157 on Subscriber Service Card

X-Band TWT

A grid-pulsed X-band traveling wave tube, the Type ZM-3280, is being marketed by General Electric Co.'s Electronic Components Div.

The air-cooled unit has a gain of 40 db. Output exceeds 10 kw from 8.5 to 9.6 GHz. Typical operation is at 22.5 kv, 4.7 amps cathode current. The device has met a shock test of 80 g's and vibration of 10 g's in accordance with MIL-E-5400 specifications.

Circle No. 158 on Subscriber Service Card

Microviewer

Maryland Telecommunications, Inc., has announced a telemicroviewer capable of resolving the very fine detail present on a 35-mm aperture card.

Model VC-9 is a time-sharing system of high resolution, capable of 1,000 TV lines in horizontal and vertical directions. A special aperture card optical and handling system, with complete control by the viewer, is used to assure maximum utilization.

The microviewer consists of a specially designed transmitter for the aperture card handling and remote monitor for viewing. It operates at a scan frequency of 1,225 lines at a 10- to 12-mc bandwidth, which permits remote monitors to be operated up to distances of 1,000 ft.

Control is handled at each remote monitor. It consists of an eight-position scanner, a magnifier for viewing of any ninth quadrant of an aperture card, and an on/off switch.

Circle No. 159 on Subscriber Service Card

Miniature Power Supplies

Data Systems Div. of Litton Industries has developed six microminiature power supplies with demonstrated reliability per MIL-R-22973 of 10,000 hours MTBF at a 99.97% confidence level.

The 5410 series delivers an average of 3 watts of regulated power per cubic inch at input/output efficiencies up to 75%. Size is reduced 80 to 90% over power supplies of comparable performance, the firm says.

The units have accumulated more than 80,000 power supply hours without a failure (80,000 hours MTBF at 63%). MIL-HDBK-217 calculations substantiate these results by predicting MTBFs ranging from 53,000 to 166,000 hours.

The constant-voltage/variable-current units, completely self-starting from 115-v ac, 400-cps, 3-phase input power, are rated at ± 3, ± 6, and ± 12v dc at 210 and 510 amperes output current. With a rectilinear form factor, they range in volume from 6.7 to 14.2 cu. in. and weigh from 0.6 to 1.4 lbs.

Circle No. 160 on Subscriber Service Card

Sweep Generator Plug-In

A 2 to 32-mc sweep and CW generator plug-in head, designed to meet the requirements of narrow-band, steep-skirt filter applications, has been announced by Kay Electric Co.

The Model P-855A operates to the highest "signal generator" standards of long and short-term frequency stability. The unit covers its frequency range in

12 overlapping direct-reading frequency bands. Two sweep width ranges are switched internally—a "wide" sweep (maximum 1 to 2% of center frequency) or a "narrow" sweep (maximum 1/20 of wide). Both ranges are continuously variable from these maximum down to residual (nominal zero).

Other specifications include: RF output of 2v RMS open circuit, 1v RMS into 50 ohms; and stability of better than ± 35 cycles, typical, below 20 mc, and better than 70 cycles, typical, above 20 mc.

Circle No. 161 on Subscriber Service Card

Recording Oscillograph

Midwestern Instruments, Inc., is marketing an optical recording oscillograph for low-cost, high-volume data acquisition.

The Model 1200 offers a 12-in. record width, 475-ft. capacity and paper speeds up to 150 ips. It has 50 active data channels, occupying 8.75 in. standard rack space. Optional features include variable channel capacity, multiple speed ranges, mercury vapor or xenon recording lamps, flash timing, trace numbering, record identification and automatic record length control. An optional rack-mounted paper take-up unit is available with or without heated platen and latensifier lamp.

Circle No. 162 on Subscriber Service Card

Stepping Switch

Haydon Switch & Instrument, Inc., is marketing a stepping switch which provides 10-step double-pole operation and is driven by the 35 series 2-wire stepper motor at rates from zero to 40 steps per second.

Current rating is 500 ma maximum. Initial contact resistance is 50 milliohm, typical; terminal contact resistance is 100 milliohm maximum. Life expectancy is 150 x 10^6 (12v dc, 100-ma load).

Circle No. 163 on Subscriber Service Card

Rear Screen Projector

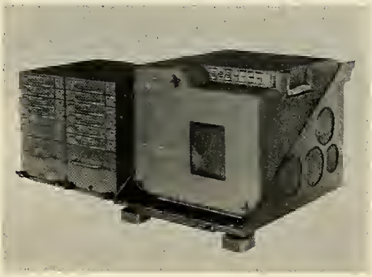
An additive color rear projector 70-mm viewer to be used in conjunction with multi-sensor reconnaissance records has been designed by Giannini Scientific Corp. under sponsorship of Rome Air Development Center.

The projector incorporates three additive color channels and one reference channel which can be simultaneously or independently scanned in X and Y modes. They are independently adjustable for X and Y translation and image rotation about the optical and X and Y axes. Each channel has 5X, 10X and 20X magnifications variable ±5%, and incorporates a film transport accommodating 100 ft. of 70-mm unperforated film.

Two rear projection screens are provided for viewing, each equipped with a movable 3X loop for additional magnification.

Circle No. 164 on Subscriber Service Card

Airborne Tape Recorder



An airborne magnetic tape recorder/reproducer, designed for anti-submarine warfare and other instrumentation applications, is announced by Astro-Science Corp.

The Model AN/AQH-1(V) uses one-inch tape and records 14 tracks of information to meet IRIG requirements. Tape speeds are 3¾, 7½, 15 and 30 ips. Bandwidths are 50 cps to 100 kc for direct record/reproduce and 10 cps to 10 kc for FM.

It meets MIL-E-5400 and MIL-I-6181D environmental and RFI specifications. Power requirements are 115v, 400 cps.

Circle No. 165 on Subscriber Service Card

Disc Memory System

A militarized disc-memory system for use as a main computer memory or buffer memory has been developed by Librascope Group of General Precision, Inc.

The L-424M system includes a disc memory that provides data storage and an electronic subsystem for the necessary interface, control and read-write electronics. Storage capacity is 25 million bits. Information storage and retrieval is fixed-address with an average access time of 25 millisecs. The unit features a flying-head design, plated cobalt recording surfaces and retractable head bars.

Data is organized in message blocks of eight 36-bit words and is written into memory 2-bit parallel, 18-bit serial. Word transfer rate is approximately 30 kc.

Circle No. 166 on Subscriber Service Card

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Charles Conrad, Jr., Edward H. White III and **Donald D. Williams:** Named to the list of Ten Outstanding Young Men of 1965 by the U.S. Junior Chamber of Commerce. Conrad, an astronaut on the *Gemini 5* mission, helped set numerous records in space travel and conducted vital medical experiments. White took the U.S.'s first space walk during the *Gemini 4* flight. Williams helped develop the systems for orbital control and attitude determination of the *Syncom 2*, *Syncom 3* and *Early Bird* communications satellites.

Brig. Gen. Arthur E. Exon: Assumed command of the Los Angeles Region, Defense Contract Administration Services. He replaces **Col. E. H. Robertson,** who will remain with the organization as special assistant to Exon.

William J. Thayer: Elected vice president of Moog, Inc. **O. Cleveland Laird** was also elected a vice president. Thayer continues as director of engineering and Laird will remain a general manager of the Hydra-Point Div.

John Feder, Jr.: Elected a vice president of Cornell-Dubilier Electronics Div. of Federal Pacific Electric Co. He will continue present responsibilities as operations manager of CDE's western division.

Robert J. Shank: Appointed vice president, Airborne Instruments Laboratory Div. of Cutler-Hammer, Inc. He will be responsible for developing a major activity for AIL in the field of transportation.

Charles W. Parker: Appointed director of the Allis-Chalmers' marketing services and public relations division and has been elected a vice president of the company. He succeeds **William J. Klein,** who retired Jan. 5.

Herbert L. Wiser: Joined Electro-Optical Systems, Inc., as a chief scientist in the space technology group. He will assist Elliott Katz in both technical management and business development with primary emphasis on research and development programs.

Kenneth W. Yarnold: Appointed director of research at System Development Corp. He is responsible for directing research in areas of mathematics, operations research, decision-making processes, artificial intelligence and information processing.

Richard M. McDonell: Appointed corporate controller of Simmonds Precision Products, Inc. He was previously manager of internal audit for the company.

Peter W. Smith: Elected executive vice president of Western Gold and Platinum Co. He will be responsible for the company's activities in each of its fields.

Leslie D. Myers: Appointed vice president of Lockheed Shipbuilding & Construction Co. **C. T. Thum** was named to succeed Myers as Lockheed Aircraft Service Co. vice president of maintenance operations. **R. L. Vader** was appointed to succeed Thum as LAS vice president of technical services and products. **Patton Lewis** was named LAS director of research and product development.

Kenneth H. Jacobs: Appointed vice president and general manager for large solid motor programs of Lockheed Propulsion Co. He will be in charge of all Lockheed's large solid rocket motor activities, including performance on existing and future Air Force contracts, proposals, studies and marketing efforts.

Daniel S. Ryter: Named controller for Raytheon Co.'s Microwave and Power Tube Div. He was formerly controller for the company's Andover, Mass., plant.

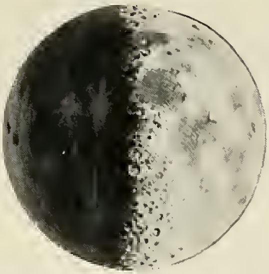
Henry Kearns: Appointed vice president for international affairs for Pike Corp. of America. He served the Eisenhower administration as assistant secretary of commerce for international affairs and was a member of the Hoover Commission Task Force on International Intelligence.

Helmut Kubeth: Joined the Anocut Engineering Co. He will conduct research on a wide range of problems involving the various aspects of electrochemical machining.

Richard C. Reynolds: Named manager of manufacturing for LFE Advanced Components, a division of Laboratory For Electronics, Inc. During the past two years, he was general manager of the military division of General Electronic Laboratories and also manufacturing manager of the Massa Div. of Dynamics Corp. of America.

Wayne L. Richmond: Joined the Rome, N.Y., staff of Planning Research Corp. He will be a senior associate in the firm's logistics systems department.

Lunar landing



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Tomorrow, Which World?

THIS NATION, and this Administration, face within the next year some major decisions about the future course of space exploration.

A committee of eminent scientists has issued a thoughtful report on the directions such exploration should take. Others have made their recommendations. Now, decisions must be made.

Should we concentrate on Earth-orbiting space stations? Should extensive exploration of the Moon follow the initial lunar landings? Should we initiate the long leadtime projects looking toward manned landings on Mars? Should we instead step up unmanned exploration of the Martian surface? Or should Venus be the focus of our efforts past the Moon?

At short range, all of these seem to offer themselves as alternatives.

History teaches us, however, that such exploration is more likely to come in waves, one overlapping the other, than in single units, each with a distinct beginning and distinct end.

Man strives for the most distant objective within reach of his technology. And as the first explorers try and try again on that far reach, others—at first, other explorers and scientists, then those scouts of commerce, miners and trappers, then businessmen, settlers and shopkeepers—follow in their wake to probe and develop what courage has proven attainable.

Perhaps the most easily understandable comparison to space exploration in our history is the exploration and development of the polar regions. Today's commercial benefits such as firs, oil from Pt. Barrow and the casual use of airlanes across the top of the world throw into shadow the gallant, dramatic and extremely hazardous efforts initially made to reach unknown areas of the Earth's surface.

It is worthwhile in attempting to look ahead at space exploration to look backward at polar exploration, particularly at the first efforts to reach the North Pole by air, for there lies the heritage of *Apollo* and the projects to follow. It is easy to forget, as we aim for the Moon, that the North Pole was first reached by air less than 40 years ago.

Each advance in technology, as it occurred, was pressed into the battle with the elements, for this was indeed a battle, not just against the unknown but against the *undone*.

The earliest recorded proposal for reaching the Pole by air seems to have come from a Frenchman who suggested to his government in 1845 that it could be accomplished by balloon.

Theory did not become reality until 1897 when the Swedish explorer Salomon August Andrée attempted to reach the North Pole with two companions in a hydrogen-filled balloon.

Why did he go? His answer, as quoted by Kurt Stehling and William Beller, now a senior editor of MISSILES AND ROCKETS, in their fascinating book "Skyhooks," rings down through the years as an answer to those who ask today why we go into space:

"I'll be giving the world something it's never had before, a knowledge of the Arctic. Is there land in the Arctic, or is it merely a mass of floating snow and ice? Will we find life there? If we do, how is it able to adapt itself to the cold? If we learn this, perhaps some day we will be able to populate that region. Oh, there are so many answers locked in that frozen area that I hope I'll have the knowledge and strength to learn even a few of them."

Andrée and his companions perished in their attempt. Their balloon went to ground three days and 300 miles from their takeoff from Danes Island on July 14, 1897. The world learned 33 years later, when their bodies and diaries were discovered, that they had died in October of 1897 while attempting to return to civilization on foot.

According to Basil Clarke in his book "Polar Flight," the first to fly an aircraft north of the Arctic Circle was a Russian aviator, Lt. Nagurski, during World War I. But an attempt to reach the Pole was not made until Roald Amundsen and Lincoln Ellsworth tried it in 1925 in the N.24 and N.25 Dornier-Wal twin-engined flying boats. That effort ended in forced landings 136 miles from the Pole and only by extreme effort did the party manage to return to Spitzbergen, having fallen short of their goal but having flown farther north than anyone before them.

THE EFFORT to reach the Pole by air finally came down to a race between Richard E. Byrd and Floyd Bennett in a three-engined Fokker powered by 220-hp Wright Whirlwinds and the Italian airship Norge under the command of Amundsen, Ellsworth and Umberto Nobile.

This was truly an international effort, with Italians, Norwegians and an American in the airship crew, and with the British and Russians providing aid enroute. It reached the Pole on May 12, 1926.

It is perhaps worth noting that it ended on a bitter note when Amundsen felt that Nobile, donning the uniform of a full Italian general on arrival in Seattle, attempted to claim all the credit. Ironically, Amundsen later was killed while on an Arctic search for Nobile, who crashed but was rescued.

Biggest disappointment of the voyage of the Norge, however, was the news that Byrd and Bennett reached the Pole in their Fokker May 9, three days earlier, to become the first airmen to accomplish the feat.

With exploration and development of the Arctic and Antarctic regions still underway, how is it possible then to say where space exploration will lead us? But polar history teaches us what courage and determination can achieve and points to the decisions we must make this year. The answer to those who ask, "Why should man go into space?" is that we have always gone.

William J. Coughlin

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JANUARY 31, 1966

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

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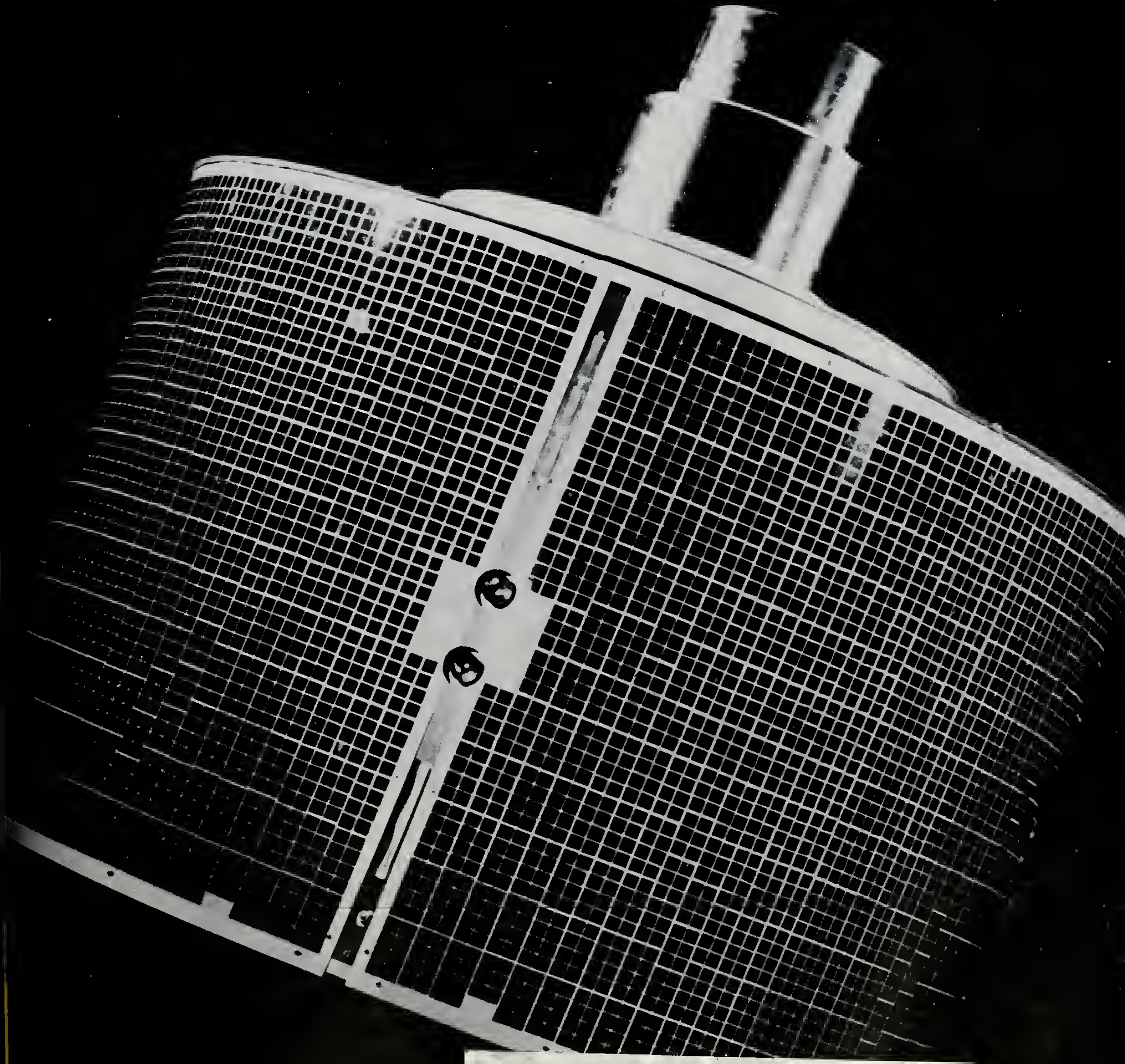
SPECIAL REPORT ON SPACE COMMUNICATIONS



Analysis of FY 1967 Budget

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satellite communication

STATE-OF-THE-ART

1958

During 1958, a tube for use in ground terminals with sufficient power and bandwidth at X-band was required for satellite communication.

At this point in time, a tube, originally developed by Varian Associates for MIT's Lincoln Laboratory was pushing the state-of-the-art in power, frequency, and bandwidth. Our scientists and engineers adapted this tube to fit all the requirements of those satellite communication terminals.

STATE-OF-THE-ART

1964

During the ensuing six years, Varian Associates' scientists and engineers made many advances in the state-of-the-art.

At this point in time, our best tubes for satellite communication ground terminals were tunable over a 2.5% frequency range, with a narrow electronic bandwidth and many features that ensured high reliability.

STATE-OF-THE-ART

1966

Working hand-in-hand with America's leading satellite communication terminal designers, Varian's scientists and engineers have built up the most thorough knowledge, capability, and technology in the entire microwave tube industry.

STATE-OF-THE-ART 1965-66: Just a few months later, Varian CW power klystrons for satellite communication terminals have advanced the state-of-the-art to:
- **tuning ranges approaching 10%**
- **bandwidths approaching 1%**

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For more information write or phone: Palo Alto Tube Division, 611 Hansen Way, Palo Alto, California. In Europe: Varian A. G., Zug, Switzerland.

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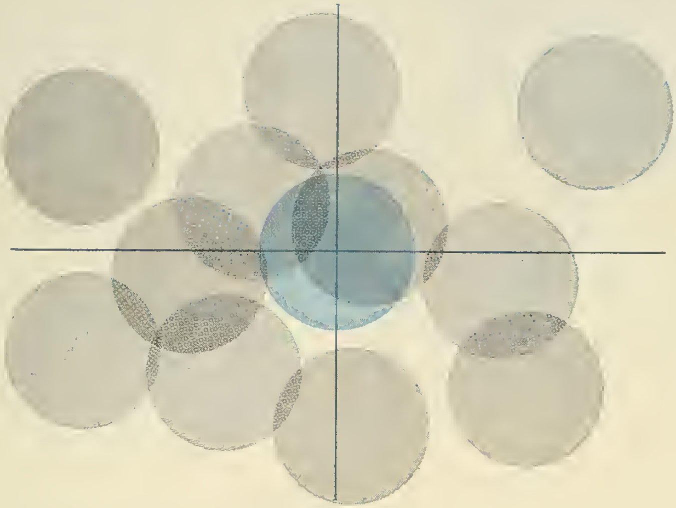
TRACKING COLLIMATION SYSTEM



NOW! MEASURE DYNAMIC TARGET DEVIATIONS TO 0.03 MILS

USAF Eastern Test Range's new tracking collimation system, developed by Canoga, now makes possible in the field real time measurements of dynamic angle tracking errors with laboratory precision.

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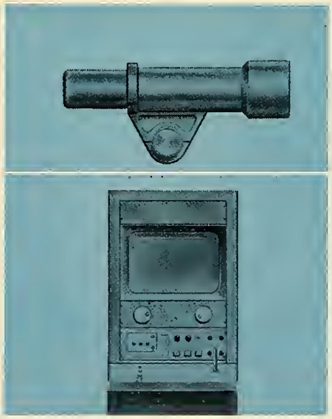
A TV camera and 80" lens is mounted on the pedestal. The system measures and automatically digitizes the angular target position within 0.03 mils. Collimator data can be directly compared with tracking data for real time evaluation of dynamic tracking performance.



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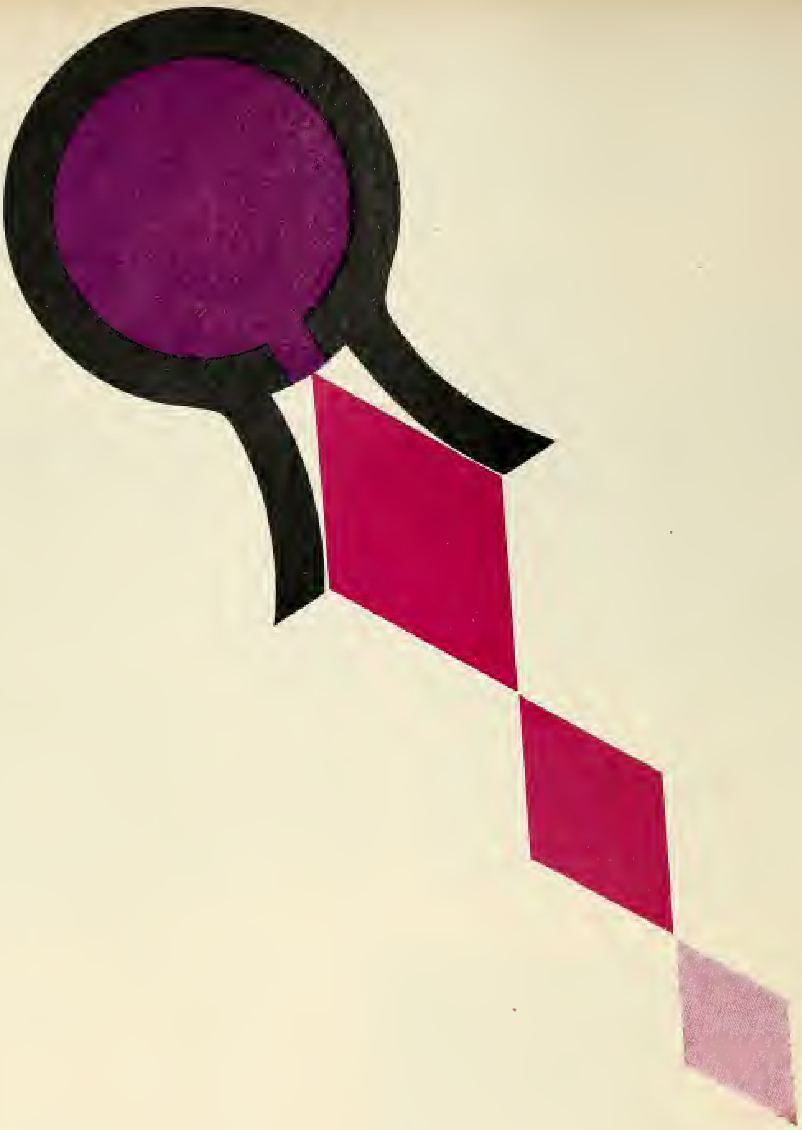

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Kidde

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missiles and rockets
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Volume 18, Number 5 January 31, 1966

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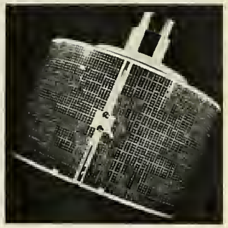
THE COVER

Model of TRW Systems Group's global communications satellite, for which Comsat Corp. is now negotiating. Satellite will provide at least 1,200 high-quality two-way voice channels and would have an operational life of at least five years. Space communications report begins on p. 34.



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collage

A random collection of fact, opinion and miscellany... some of it a blatant attempt to peddle the products and capabilities of Motorola's Military Electronics Division.

If this looks vaguely familiar it's because you've probably seen our humble little periodical that also bears the name, COLLAGE. In a bold effort to save a little time and a few bucks some genius in the Motorola hierarchy decided we ought to print a few of its less censorable items in high-class magazines like this.

At the forefront etc. Department

Our Chicago Center has developed a solid-state light deflector composed of alternate crystals of electro-optical materials and birefringent calcite. It is capable of both matrix and continuous character generation, and can distribute information onto photosensitive media or display screens. As of press time, no one is quite sure if we are selling these things or just bragging. If you get nasty though, we may send a recent *Engineering Bulletin* that tells about it. We're also pretty big on high-speed non-impact printers, but that's a story all in itself that we'll save for a later day.
For more information, write to our Chicago Center.

Continued on page 49

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letters

The Downhill Path

To the Editor:

I concur very solidly in the position taken in your editorial of Jan. 10, "The Downhill Path." The misuse of such power in clubbing private enterprise is inexcusable—and private enterprise does itself and the country a disservice by cowering.

I. E. Wetmore
Groton, Conn.

Astrolog Alteration

To the Editor:

Just noticed your newest Astrolog and believe *Subroc* needs some revision. In the status section you can say that it is in full production and is being installed on Permit class submarines. The Permit designation was adopted after the sinking of the Thresher. Operational evaluation has been completed and the missile now is being deployed in the fleet.

William V. Levy
Manager, Public Relations
Goodyear Aerospace Corp.
Akron, Ohio

Sheridan and Shillelagh

To the Editor:

The article on the combustible cartridge for the General Sheridan Weapon System (*"Shillelagh* Round To Boast Fully Combustible Casing," M/R, Jan. 10, p. 38) has been brought to the attention of this office.

The Sheridan Weapon System is just one of many weapon systems managed by Army Weapons Command. The Project Manager, Sheridan Weapon System, has his office at this headquarters. He is responsible for *all* phases of development from inception through operational use.

After reading the article, a knowledgeable member of the Project Manager's office pointed out some misstatements of fact. The combustible case about which the author wrote is *not* a component of a companion round to the *Shillelagh* as stated in the first paragraph, nor is the case for the *Shillelagh,* as stated in the second paragraph.

A more accurate description of the combustible case, after it has been primed, fuzed and loaded, would have been "a companion round for the Sheridan." *"Shillelagh"* only describes the guided missile. The Sheridan Weapon System includes the missile, conventional (rifled) ammunition, gun/launcher, firing controls, and assault vehicle.

The *Shillelagh* guided missile is only one type of a wide variety of ammunition which will be available to the commander of the Sheridan assault vehicle. Combustible cases are being produced for three types of "conventional" ammunition including High-Explosive Anti-Tank with a capability of defeating either soft or hard targets; White-Phosphorus-Smoke; and Training Practice.

Budd A. Willetts
Information Office
Headquarters, U.S. Army
Weapons Command
Rock Island Arsenal, Ill.

Fuel Contaminants and GT-7

To the Editor:

I have just read an article about the *Gemini 7* astronauts' attempt to complete optical experiments. They stated that the windows were fogged sufficiently to degrade any measurements that were made.

Reportedly, Manned Spacecraft Center does not know where these contaminants came from. Several ideas were advanced that they were caused by salt spray or air pollution in the atmosphere adhering to the statically charged spacecraft.

I should like to add a viewpoint with the backing of some experimental data. We have just completed a simulated high-altitude test in connection with work done for Marshall Space Flight Center to measure fuel contaminants and their effects on various surfaces. Some of these experiments were optical and we measured signal attenuation on lens surfaces up to 30% for pieces of equipment as far away as 25-35 ft. from the center line of rocket exhausts. The rockets tested were S-IVB retro motors firing over a full-scale model at 131,000 ft. It has been observed that as the altitude increased, the expansion of the exhausts increased and the contamination on the model and all equipment surfaces increased. These contaminants had the "greasy" appearance described by the astronauts because of the very small size of the contaminants (.2μ to 1μ of Al_2O_3 solid particles).

Frank J. Leslie, Jr.
The Boeing Company
Huntsville, Ala.

Weltschmerz

To the Editor:

I'm tired of knocking myself out at the ten o'clock meeting so the guys in the one o'clock meeting can dream up a good story for the three o'clock meetings. This business used to be fun when a launch procedure consisted of a bunch of us asking each other if we were ready and then letting our beer cans try to fly but all that disappeared when the procedure writers took over. Perhaps it's better this way but I don't like it so I'm getting out. Erase my name from everything connected with this business and forward my mail care of RFD, Oconto, Nebraska. From now on, I raise cows and the only birds I'm concerned with sing real songs.

Richard L. Davis
Santa Maria, Calif.

P.S. I did enjoy the hell out of your editorials for the most part.

How to squeeze a 100-ft. antenna into the palm of your hand.

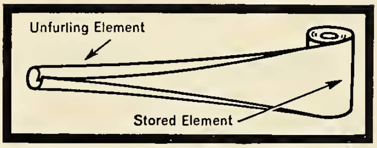
The de Havilland answer: STEM* pop-out antenna.

With all the astonishing advances made in space technology, three requirements for all space equipment remain unchanged: compactness, simplicity, reliability.

And that goes for antennas too. Applying the STEM principle the de Havilland engineers developed such an expandable antenna. In its container, it's so small you can hold it in your hand. Yet the antenna pops out to 100 feet when the restraining latch is released by remote control.

Right now this STEM antenna is being used on Gemini space craft for orbital communications and is in orbit on other space craft. De Havilland has adapted the STEM principle to many other space applications as well. Applications such as space craft docking booms, gravity gradient stabilization booms, instrumentation booms and proximity sensors.

If you would like more information about de Havilland STEM devices and their many uses, simply write to the Chief Applications Engineer.



*The STEM Principle (Storable Tubular Extendible Member). Strip metal is heat-treated into a circular section so that edges overlap by about 180°. Starting at one end, the tube is unbent and wound flat onto a roll, under strain. This gives it a natural tendency to unwind and become a tube again. This stored energy is used to unfurl the STEM mast in expandable "jack-in-the-box" antennas. The tube can also be powered by motor for extension and retraction. Damaged masts are easily replaced by installing a new storage drum. The unfurled tube has a bending strength almost equal to a seamless tube of the same diameter and thickness.

THE DE HAVILLAND AIRCRAFT OF CANADA LIMITED
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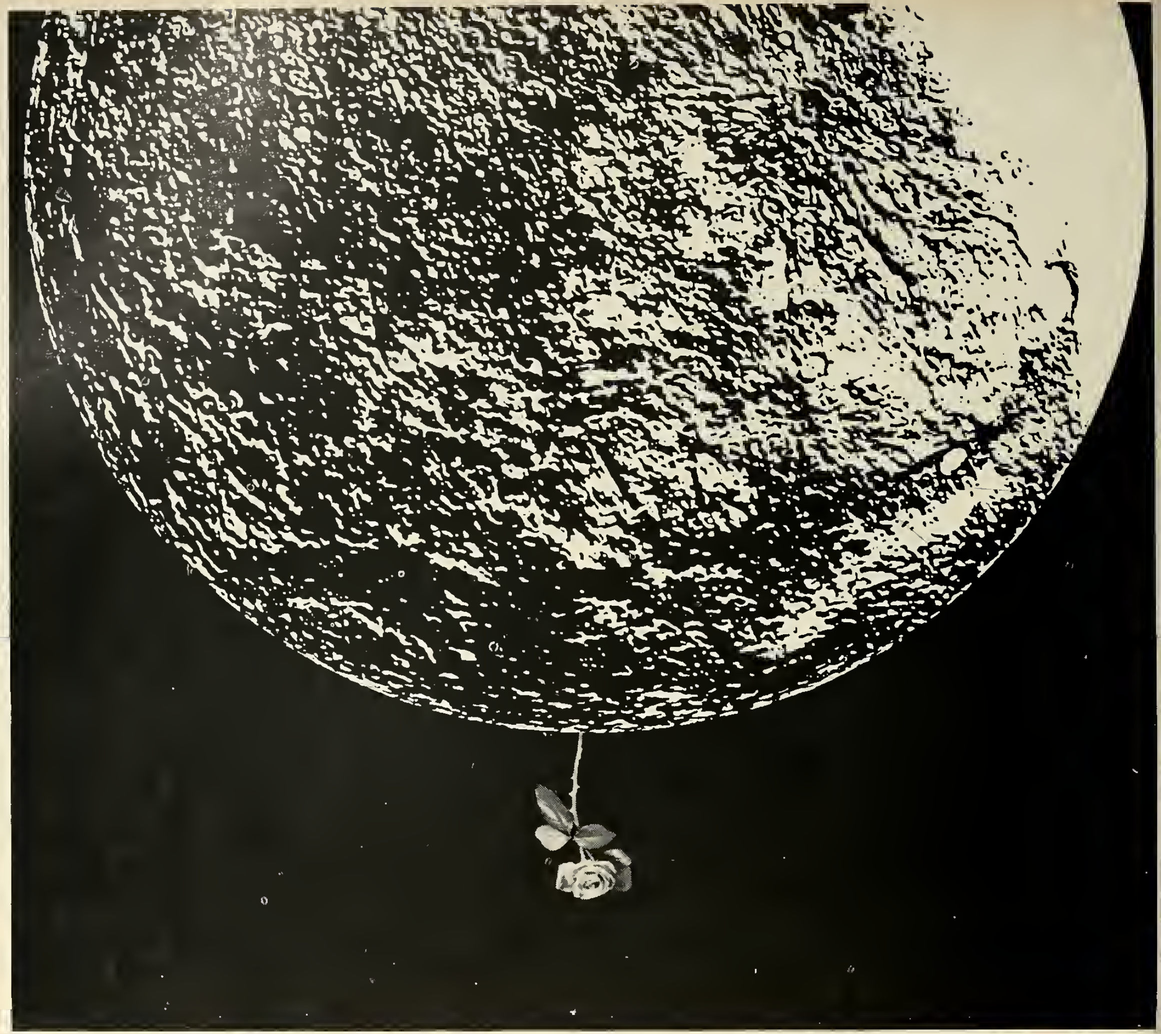

life after earth?

We're helping NASA find the answer as well as probing vital questions of the here and now. Our major programs include LEM inertial guidance system, LEM descent engine, Gemini and Apollo mission analysis, OGO satellites, advanced ballistic missile studies, underwater defense systems, Pioneer interplanetary spacecraft, communications satellites, advanced space probes, Vela nuclear detection satellites, Mars mission studies, telemetry, tracking and control systems, Apollo application studies, advanced propulsion systems, and electronic warfare systems. These create openings in Inertial Guidance and Control Systems; Mission, Trajectory and Guidance Analysis; Semiconductor Applications; Radar and Sonar Systems; Communications and Telemetry; Experimental Mechanics; Dynamics and Structures Analysis; Aerophysics; Re-entry Systems; Spacecraft Heat Transfer; Space Propulsion Systems; Microelectronics; and Systems Research, Development and Analysis. Why not write us. TRW Professional Placement, One Space Park, Dept. B-15, Redondo Beach, California. TRW is an equal opportunity employer, male and female.

TRW SYSTEMS

The Countdown

WASHINGTON

Martin Chosen for Walleye Production

Martin Co.'s Orlando Div., as expected (Countdown, Dec. 6, p. 9), has won the Navy competition for production of *Walleye,* a 1,100-lb. TV-guided glide bomb. Initial contract is for $12 million; however, future procurement is expected to be very heavy. An Air Force buy is also expected.

First TOS Launching at Hand

The initial *Tiros Operational Satellite* (*TOS*)—which will be called *ESSA 1* (Environmental Science Services Administration) if successfully placed in orbit—is scheduled for launch no earlier than Feb. 2. Another early February launch is the *Scout* re-entry test slated for Wallops Island no earlier than Feb. 7.

SRAM To Add Muscles to FB-111A

Classified data presented by Secretary McNamara to the House subcommittee investigating recent bomber cutbacks includes the statement that "on a typical nuclear strike mission the range of the FB-111A exceeds that of the B-52 C-F's and the B-58." Officials say the FB-111A can carry as many as 50 conventional 750-lb. bombs. Development of the *SRAM (Short-Range Attack Missile)* for the new aircraft is directed toward providing a range of trajectory options for the missile to confuse virtually any defense set up against it.

NASA-Comsat Ties Bother Senators

The relationship between NASA and the Communications Satellite Corp. is causing some concern among members of the Senate Space Committee, which held hearings on the matter last week. One question involved: Should Comsat Corp. be charged for the benefits it receives from NASA research and development of advanced communications techniques?

Gemini 8 May Include Rescue Drill

A space rescue may be attempted during the upcoming *Gemini 8* mission. Pilot David R. Scott may simulate a maneuvering gun failure while he is suspended in space at the end of a 100-ft. tether. Neil A. Armstrong, command pilot, would then maneuver the spacecraft, using Orbital Attitude Maneuvering Systems thrusters to rescue the "passive" astronaut. In a separate exercise, Scott may evaluate the dynamics imposed by the tether during hand-over-hand return to the *Gemini.*

TRW To Make OGO Flight Model

TRW Systems has been awarded an estimated $9 million to convert the prototype *Orbiting Geophysical Observatory (OGO)* into a flight spacecraft. The converted prototype will be called *OGO F* and will be the sixth launch in the series.

Signs of the Times

A footnote was attached to estimates of U.S. fatalities associated with various defense postures outlined by Secretary McNamara last week before a House Armed Services subcommittee (see p. 10). It indicated that the number of deaths resulting from a nuclear exchange was "rounded to the nearest five million."

INDUSTRY

Defense Stocks Busy on Wall Street

Budget and military discussions last week caused record activity in defense stocks, which as a group hit one of the highest peaks in several years. Two stocks—Douglas Aircraft and Ling-Temco-Vought—have tripled in value since Jan. 1, 1965.

Convair Ground-Testing PRIME Systems

Convair Division of General Dynamics is conducting ground tests for Air Force's *PRIME (Precision Recovery Including Maneuvering Entry)* vehicle program at the Pt. Loma test site in San Diego. Work to be carried out through September includes structural tests of the adapter section, match-mate tests of hardware to be assembled in a 66-ft. tower, re-entry vehicle release system tests on an air-bearing stand, and testing of the jettison system for the re-entry vehicle fairing. Four *PRIME* vehicles will be launched from Vandenberg AFB beginning late next year, with aerial recovery by C-130 aircraft near Kwajalein.

Lockheed Developing Thermal Test System

Lockheed-California Co. will produce a test system that experimentally evaluates thermal controls for space vehicles under a $185,000 contract with Air Force Systems Command. System components will be tested under simulated space conditions at the Lockheed Rye Canyon research laboratory.

PRC Wins Second Traffic Planning Job

The City of Portland, Ore., has retained Planning Research Corp., of Los Angeles, to study its traffic control system and recommend improvements in effectiveness. PRC, which is performing a similar but more complex study for Washington, D.C., said the work could produce recommendations involving total computer control of the signal system.

Systems Approach to Army Medicine Studied

First results of a study by Daniel, Mann, Johnson & Mendenhall, Los Angeles, on feasibility of applying systems planning, analysis and operations techniques to improve the management of existing military medical facilities will be submitted to Dept. of Defense on Feb. 18. The architectural-engineering firm is one of four companies commissioned by DOD for the study, conducted through the Army Medical and Research Development Command.

INTERNATIONAL

Nord-Aviation, Boelkow Form Joint Company

Nord-Aviation of France and Boelkow GmbH of West Germany have created a joint company for the sale of the tactical missiles *(Roland, Milan, Hot)* that the two firms are developing jointly. Headquarters will be in Paris.

DOD Reassesses Red Threat

An unclassified version of testimony presented last week to a House Armed Services subcommittee by Defense Secretary Robert S. McNamara reveals for the first time the extent of the official concern over Communist China as a potential nuclear threat to the United States.

The statement—which some U.S. officials say is probably the most unique defense document ever openly published by any country—also reflects the Defense Secretary's optimism, if not fiscal commitment, regarding effectiveness of a limited anti-ballistic missile defense vis-à-vis the Chinese threat.

The testimony was presented to the subcommittee investigating the strategic bomber cutbacks announced while Congress was not in session (M/R, Jan. 17, p. 15).

The report was also significant in that it presented, for the first time, 1) estimates of the ability of those U.S. forces charged with assured destruction of enemy targets to complete their mission in the face of a Soviet ICBM force and 2) a defensive posture considerably better than that now postulated by U.S. intelligence.

Here are the key points:

—If, in 1970, the Soviets assigned their entire available missile force to a suprise attack on U.S. strategic forces, "a very large proportion of our alert forces would still survive . . . and deliver their payloads. The effective delivery of even one-fifth of the surviving weapons on Soviet cities would destroy about one-third of the total population and half of the industrial capacity of the USSR. A considerably smaller number of weapons," the report states, "detonated over 50 Chinese urban centers would destroy half of the urban population (more than 50 million people) and more than half of their industry.

"Thus, without any use of the bomber forces, the strategic missile forces recommended for the FY '67-71 period would provide substantially more force than is required for the assured destruction capability against both the Soviet and Chinese simultaneously."

—On the role of the manned bomber, the Secretary first states that "we are quite confident that the Soviets do not now have, and are most unlikely to have during the next five years, the ability to inflict high levels of pre-launch attrition on our land-based missiles, or any attrition on our submarine-based missiles at sea."

However, in order to determine how best to hedge against the possibility that missile forces may turn out to be less reliable than now estimated, alternatives for additional forces were analyzed.

The results showed that "only when missile effectiveness falls to less than about 50% of what we actually expect are bombers less costly than missiles for insurance purposes. Against current Soviet bomber defense, the B-52G and H force is adequate to hedge against complete failure of the U.S. missile force for assured destruction purposes. Against improved Soviet bomber defenses," according to the Secretary, "our missile effectiveness could turn out to be 30% of what we expected before we would wish to insure with FB-111/*SRAM*-equipped aircraft rather than missiles."

On the role of damage limitation for the U.S., the Secretary made the following points vis-à-vis the USSR:

—"We should not now commit ourselves to a particular level of damage limitation against the Soviet threat—first, because our deterrent makes general nuclear war unlikely, and second, because attempting to assure with high confidence against all reasonably likely levels and types of attack is very costly, and even then the results are uncertain."

—Against likely Soviet postures for the 1970's, an appropriate mix of damage-limiting forces, including a full fall-out shelter program, ballistic missile and sub-launched missile defense, and improved bomber defenses, "could affect substantial reductions in the maximum damage the Soviets could inflict, but only at substantial additional cost." Even with this, he reported, "there would be little hope of reducing fatalities below 50 million persons. Improvements to U.S. ICBM's used against Soviet hard targets could aid in damage limitation, but this is very "sensitive to the timing of any exchange."

—An ABM system employing long-range exo-atmospheric intercepting missiles in addition to lower-altitude ones could complicate a sophisticated attacker's problem, the Secretary admitted, but he quickly added: "this conclusion is based on a preliminary analysis and there are many unresolved questions about the design and performance" of such a mixed system.

Regarding the Chinese threat, McNamara made these points:

—During the past year, the potential of a Chinese nuclear threat to the U.S. has become more real "and the feasibility of a moderately priced defense against it more promising." The Chinese "could possibly develop and deploy a small force of ICBM's by the mid- to latter-part of the 1970's."

—"A light anti-ballistic missile system using exo-atmospheric interceptors and terminal defense at a small number of cities offers promise of a highly effective defense against the type of attack the Chinese Communists might be capable of launching within the next decade. The initial investment and five-year operating cost, including R&D, would be about $8 to $10.5 billion depending upon the number of cities protected." (Officials also admit that the submarine-based missile threat may be upon us sooner, and say that some work is under way to defend against it.)

—It appears that such a defense would remain highly effective for some time, and could be augmented as necessary for expansion.

—"On the basis of our present knowledge of Chinese Communist nuclear progress," the Secretary said "no deployment decision need be made now. However, the development of the essential components should be pressed forward vigorously."

DOD Saves $4.8 Billion in FY '65

The DOD cost reduction program instituted by Secretary Robert S. McNamara has resulted in savings of $4.8 billion in FY 1965.

McNamara assured the Joint Economic Committee's subcommittee on federal procurement and regulation last week that the savings made in the program "were made without adverse effect on our military strength or combat readiness. Any doubt of this can only be based on a misunderstanding of the way in which we compute our requirements for forces, equipment, and ammunition."

McNamara said that savings were realized in three general categories: buying only what is needed, $2.5 billion; buying at the lowest sound price, $1.2 billion, and reducing operating costs, $1.1 billion. He added that he believed that $6.1 billion could be saved in FY 1969 and every year thereafter.

Shots of the Week

NASA wound up its *Apollo* escape system test Jan. 20 with the successful launch of a *Little Joe II* booster from White Sands Missile Range, N.M. Firing of the launch escape system was made during maximum (Q) conditions. Five flights were made previously in the series. Four were successful. The system will be shipped to Cape Kennedy to be mated to a *Saturn IB* rocket.

- An advanced *Minuteman* ICBM was fired Jan. 22 from Vandenberg AFB as part of a test of a modernized *Minuteman I* silo.
- The Soviet Union orbited *Cosmos 105* and *106* on Jan. 22 and 25.
- The Air Force fired an *Athena* test missile from Green River, Utah, on Jan. 21.

Small Business Money Up

First results on Fiscal Year 1965 show small businesses increasing their share of defense prime contracts. Total DOD small business for the first two months of FY '65 is $205 million ahead of FY '64, which was a record breaker itself.

During FY 1965, DOD officials told the Senate small business procurement subcommittee Jan. 26, small businesses received $5.035 billion in prime contracts, an increase of $463 million over FY 1964. This was the highest dollar volume since FY 1952.

In those subcontracts which were reported in the Defense subcontracting program, small businesses received $3.534 billion in FY 1965, compared with $3.629 billion in FY 1964.

AEC Stresses Radioisotopes

The Atomic Energy Commission is increasing its development and production program over a broad spectrum of radioisotopes to meet requirements projected by NASA, DOD and other users.

AEC Chairman Glenn T. Seaborg told the Joint Committee on Atomic Energy Jan. 26, that work on the development of isotopic power and heat source fuels accounts for a large portion of the 1967 estimate for the AEC isotopes development program of $14.8 million (see p. 30), amounting to $6.5 million.

Apollo Ships Money Revealed

Shipboard equipment in support of the *Apollo* communications satellite system for which NASA is contracting with Communications Satellite Corp. will cost $22.5 million, bringing costs of the whole service to over $100 million.

NASA Deputy Administrator Robert C. Seamans told the House military operations subcommittee last week that the $22.5 million represents equipment which NASA is procuring itself to outfit three tracking ships for satellite communications. Value of the contract over a 10-year period is estimated at about $80 million, although negotiations continue.

In testimony before the Senate Space Committee, which is looking at the whole area of communications satellites work, Deputy Associate Administrator Earl D. Hilburn said that NASA actually has been conducting negotiations with four companies.

In addition to Comsat Corp., he said, which will provide the Earth stations in the U.S. and satellite links to the three ships, the Australian Overseas Telecommunications Commission will provide the Earth station at Carnarvon and the link to the satellite, Hilburn said. In addition, Britain's Cables and Wireless Ltd. is providing similar services at Ascension Island, while Compania Telefonica Nacional De Espana of Spain is providing services at the Canary Islands.

NASA Lunar Experiments Set

Seven geophysical instruments have been chosen as the primary and backup experiments which will be left on the Moon on the initial lunar landing missions.

The package of experiments—called *Apollo* Lunar Surface Experiments Package (ALSEP)—will weigh about 150 lbs. The instruments are expected to transmit for six months to one year.

The experiments are the passive lunar seismic experiment, lunar triaxis magnetometer, medium-energy solar wind experiment, suprathermal ion detector, lunar heat flow measurements experiment, low-energy solar wind experiment, and the active lunar seismic experiment.

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The BA-102 Series can be used in conjunction with PCM serial simulators to measure bit error rate of PCM processing systems. Operation is provided at bit rates from DC to 2 megacycles with data I/O threshold adjustable from +7 to —7 volts.

The power supply is self-contained and input/output connections are provided on both the front and the rear of the unit. A built-in delay to compensate for delay of the processing system under measurement is also provided.

For additional information write for Bulletin BA-102.

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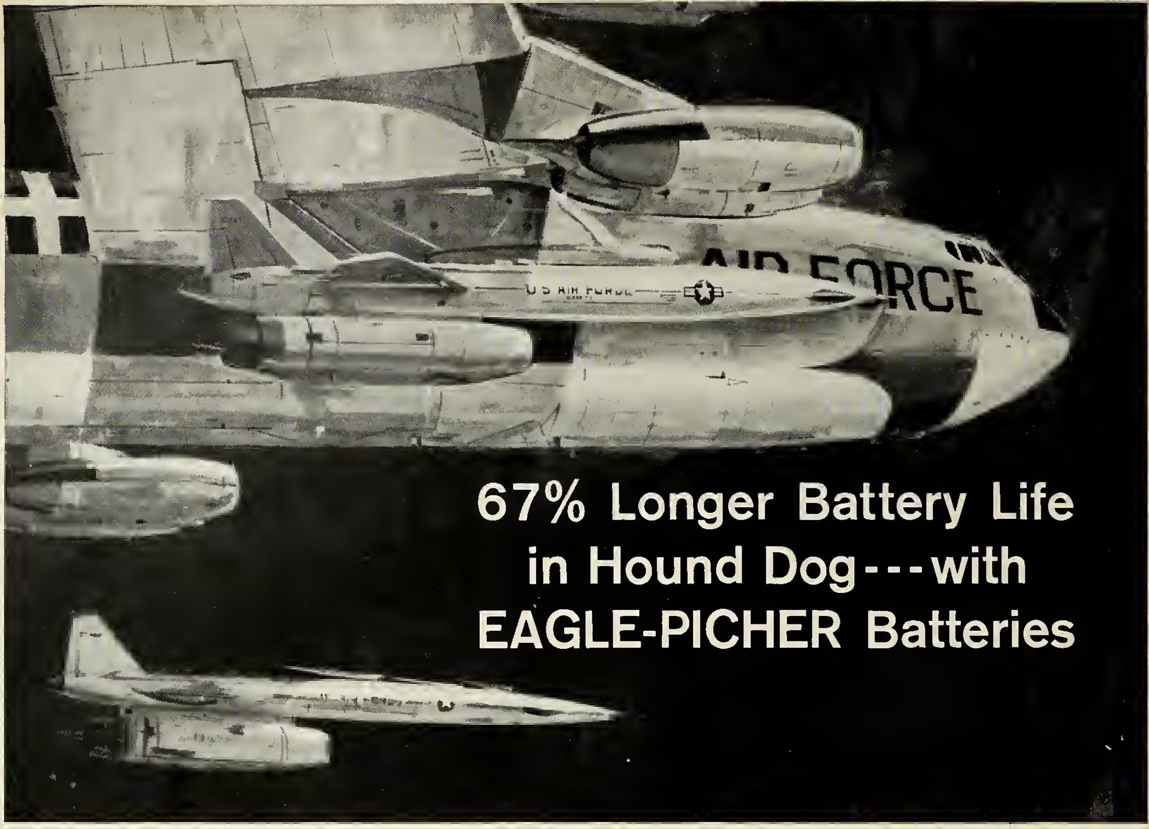

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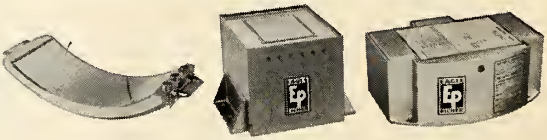

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THE BUDGET
OF THE UNITED STATES GOVERNMENT
FISCAL YEAR ENDING JUNE 30 1967
THE BUDGET OF THE UNITED STATES GOVERNMENT • 1967

a special report:

FY '67 BUDGET

- **Vietnam pushes military procurement up**
- **Apollo cut to crucial edge**
- **Missile spending jumps substantially**
- **MOL faces stretchout**
- **Nike-X continues in R&D**

$30.03 Billion for the Industry

Actual DOD and NASA expenditures will be $1.741 billion above total for FY 1966, although obligational authority will decline

CONGRESS CONTINUES hearings this week on a record Administration budget which calls for spending of $30.039 billion in defense and space funds with this industry.

Senate and House appropriations and authorization committees lost no time in tackling a Fiscal 1967 budget asking for overall Dept. of Defense spending of $57.2 billion and NASA expenditures of $5.3 billion, heaped on top of a towering $12.7-billion FY '66 supplemental for Vietnam.

Impact of the supplemental has blurred the usual clean line between fiscal year budgets. Thus, while actual expenditures for DOD will rise sharply in FY '67, the total obligational authority (TOA) and new obligational authority (NOA) figures decline from what will be the new FY '66 totals if the supplemental is approved on Capitol Hill as expected.

Expenditures up—In terms of expenditures, the money to be spent with this industry in FY '67 will be $1.741 billion higher than the $28.298 billion now to be spent in Fiscal '66.

That includes DOD expenditures for procurement and research, development, test and evaluation (RDT&E), the NASA and AEC budgets, and advanced technology portions of the Atomic Energy Commission and Commerce Dept. budgets. It does not include DOD personnel and operational funds, which, for the most part, are not spent with industry.

The $0.7-billion authorization granted in FY '65, the $1.7-billion NOA add-on passed in August, and the $12.7-billion FY '66 supplemental just submitted to Congress (M/R, Jan. 24, p. 13) are all applicable to the FY '66 budget. They have swelled the FY '66 TOA and NOA totals to $66.5 billion and $63.3 billion, respectively.

DOD officials point out, however, that of the more than $15 billion NOA requested in supplementals thus far for Vietnam, only $4.6 billion actually will be spent in FY '66.

Net effect of this has been to take some of the onus off the DOD FY '67 request in comparison to this year's budget, although upping the actual spending sharply in FY '67.

Defense officials also left the door open to more FY '67 supplementals "if the level of intensity of the war in Vietnam increases dramatically."

Lunar cliffhanger—While the trend of Dept. of Defense spending was sharply upward, the budget for the National Aeronautics and Space Administration took a downward turn for the first time in eight years.

NASA officials left little doubt that budget restrictions are cutting the chances of landing Americans on the Moon in this decade to the thinnest possible margin. The lunar landing still can be accomplished, in the NASA viewpoint, but nothing is left for contingencies should a major setback arise.

A major casualty in NASA budget planning was the *Apollo* Applications Program, which has been left with a budget which barely will keep it alive until next year.

This raises the spectre of a gap between the end of the *Apollo* lunar landing program and the follow-on project of lunar- and Earth-orbital exploration with *Apollo* hardware. Whether such a gap develops and just how wide it would be depends in great part on the success in achieving an early lunar landing.

As President Johnson pointed out in his budget message to Congress on Jan. 24, savings in the NASA budget have been accomplished because *Apollo* spending now is peaking out and no equivalent projects are being initiated.

Only two new programs of major potential get any new funding whatever. AAP directly receives only $42 million in new obligational authority, in comparison with the $200 million NASA requested. Another $25 million for lunar experiments will benefit AAP and carry-over from the FY '66 budget will result in a total expenditure of some $100 million on AAP during FY '67. *Mariner* will be funded at $26.1 million for flights to Venus and in 1967 and to Mars in 1969.

Big solid motors will be kept perking at a level which might make it possible for the option to be picked up in the FY '68 budget. The M-1 engine was a casualty of the budget squeeze but the SNAP-8 nuclear project managed to escape the shears.

Some missile advances—On the DOD side, the *Short Range Attack Missile (SRAM), Minuteman III* and *Poseidon* were among strategic weapons getting a thumbs up, while a number of tactical missiles will be among the 52,297 missiles for which DOD asked FY '67 new obligational authority.

Nike-X will continue in the research and development phase, with slightly more than the $400 million allotted in the current fiscal year. Secretary of Defense McNamara, however, raised hopes of production funding for the lightweight anti-ballistic missile version when he told a House subcommittee last week that it appears very promising as a weapon against the potential Chinese threat.

Manned Orbiting Laboratory, a budget casualty, will have to get along with about the same amount of funding for FY '67 as in FY '66 instead of an anticipated increase. Carry-over funds, however, will make it possible to actually spend some $250 million on *MOL* in FY '67. ■

Missiles Gain, Space Suffers at DOD

A SHARP UPTURN in new obligational authority (NOA) for missiles and a leveling off of military space spending are major features of the Fiscal Year 1967 Dept. of Defense budget.

NOA for missile procurement increased by $333 million to $1.9 billion in FY '67, and missile RDT&E NOA rose by $392 million to $2.3 billion in FY '67. Expenditures for missile procurement will slip very slightly from FY '66 but RDT&E expenditures are estimated to increase by more than $200 million, making a net increase in both NOA and expenditures for all missile work in FY '67.

The figures reflect a major increase in attention to tactical missiles by the DOD, especially air-to-surface weapons, which have suffered in comparison to other weapons in terms of development over the past decade.

Space figure disappoints—Military space spending, according to DOD officials, will total $1.6 billion for FY '67, slightly less than in FY '66 although these figures appear in no one place in the budget. The fact that the $1.6 billion comes close to last year's total should provide no real consolation to an industry that had expected an expanding effort.

Largest portion of the military space spending, the military astronautics category within RDT&E, shows a decline from $1 billion this year to $843 million in FY '67. A large portion of this is attributable to a sharp drop in RDT&E funds for *Titan III.*

The budget includes only about $150 million for the Air Force *Manned Orbiting Laboratory (MOL).* This is about the same level as in FY '66 and is admittedly far below what early DOD estimates had called for in FY '67. While DOD officials insist there has been no change in attitude, relative importance, or schedule for the project, it is widely held by Pentagon observers that program stretchout is indeed taking place.

DOD officials lent some credence to this feeling when discussing the question of flight schedules, indicating that the initial goal to get the first manned flight off in 1968-69 was not critical.

While *MOL* authorizations will remain the same, actual expenditures in FY '67 will increase substantially.

The remainder of the military space expenditure is for construction, which does include funds for *MOL* work at Vandenberg AFB, ancillary costs, and probably for the unpublicized procurement and RDT&E on military reconnaissance satellites.

The space spending will also include RDT&E funds for the replenishment launch of the initial military communications satellite system to be in service in 1967 and for a start on the more advanced system (see special report—p. 58).

The NOA requested for FY '67 will provide funds for purchase of 52,297 missiles, 1,078 fixed-wing aircraft, 1,673 helicopters, and 51 ships (either conversions or new vessels).

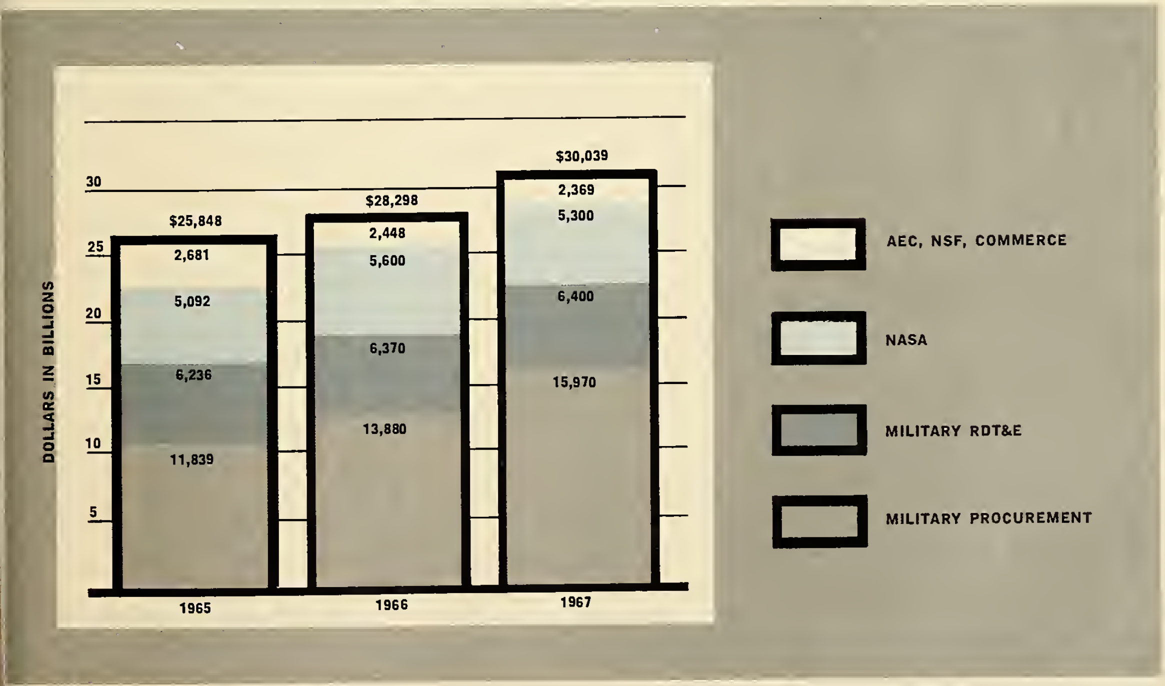
These figures, plus the 4,830 missiles, 2,005 helicopters, and 900 fixed-wing aircraft asked for in connection with the FY '66 supplemental now before Congress, provide a vivid picture of the extent of the U.S. build-up to meet the needs of war in Vietnam and the threat of similar war elsewhere in the future.

A breakdown of the FY '67 budget in terms of the key new programs follows:

Minuteman III added—Major items include R&D and initial procurement of *Minuteman III,* an advanced version of the system said to incorporate a change in kill probability beyond *Minuteman II* which is so great as to justify a change in designation.

The existence of the *Minuteman III* program was disclosed exclusively in Missiles and Rockets (Dec. 13, p. 7).

Fiscal year 1967 spending for the missile/space industry in millions of dollars. Dept of Defense figures are adjusted to show portions of the FY '66 supplemental that are to be spent in FY '66 and FY '67 respectively.



PROCUREMENT FY 1966-1967

(Millions of Dollars)

FUNCTIONAL CLASSIFICATION	DIRECT BUDGET PLAN (TOA)		NEW OBLIGATIONAL AUTHORITY		EXPENDITURES	
	FY 1966	FY 1967	FY 1966	FY 1967	FY 1966	FY 1967
AIRCRAFT						
Army	1,333	592	1,311	592	299	854
Navy	3,224	1,612	2,791	1,422	1,801	2,163
Air Force	5,596	4,355	5,261	3,961	3,900	3,700
Total	10,153	**6,560**	9,363	**5,976**	6,000	**6,717**
MISSILES						
Army	369	356	341	356	118	224
Navy	424	385	427	385	544	472
Air Force	1,243	1,240	840	1,190	1,210	1,055
Total	2,036	**1,981**	1,608	**1,931**	1,872	**1,751**
SHIPS—Navy	1,930	**2,041**	1,590	**1,751**	1,650	**1,700**
TRACKED COMBAT VEHICLES						
Army	376	359	292	359	179	277
Navy	13	4	13	4	10	10
Total	389	**363**	306	**363**	189	**287**
ORDNANCE, VEHICLES, AND RELATED EQUIPMENT						
Army	2,031	1,648	1,564	1,448	1,126	1,162
Navy	1,628	1,370	1,500	1,301	640	1,231
Air Force	1,445	1,545	1,370	1,469	348	1,009
Defense Agencies/OSD	2	1	2	1	2	1
Total	5,105	**4,564**	4,436	**4,218**	2,117	**3,403**
ELECTRONICS AND COMMUNICATIONS						
Army	450	293	334	268	312	360
Navy	470	417	406	369	294	353
Air Force	447	225	424	214	387	313
Defense Agencies/OSD	10	28	4	28	9	21
Total	1,377	**963**	1,167	**879**	1,001	**1,048**
OTHER PROCUREMENT						
Army	487	312	332	288	236	343
Navy	738	564	657	540	381	396
Air Force	434	463	412	439	410	308
Defense Agencies/OSD	26	24	9	22	24	18
Total	1,685	**1,363**	1,411	**1,289**	1,051	**1,064**
TOTAL—PROCUREMENT						
Army	5,045	3,561	4,174	3,311	2,270	3,220
Navy	8,428	6,392	7,385	5,772	5,320	6,325
Air Force	9,165	7,827	8,307	7,273	6,255	6,385
Defense Agencies/OSD	37	54	15	51	35	40
TOTAL	22,676	**17,834**	19,881	**16,408**	13,880	**15,970**

The new re-entry vehicle, which is the only change, probably includes multiple warheads and some degree of maneuverability. Two advanced re-entry vehicles are under development for *Minuteman*, the Mk 12, being developed by GE, and the Mk 17, being developed by Avco. The former is much further along in development.

Funds are also provided to bring the total *Minuteman* ICBM force to 1,000 by the end of FY'67. This involves adding four 50-missile squadrons. The first 10 *Minuteman II's* became operational in October, and at least a squadron is expected to be in place by the end of FY'66.

FY'67 also includes an increment of the development costs for the airborne launch control system for the *Minuteman* force. Several EC-135 aircraft were added to this Post-Attack Command and Control System (PACCS) last year. Development cost of the equipment is placed at $18.6 million through FY'67.

The 54 operational *Titan II* missiles will be retained in service.

FY'67 procurement of *Polaris* missiles will allow the entire planned force of 656 missiles aboard 41 submarines to be operational by the first quarter of FY'68. The force will include 13 SSBN's with 1,500-mile-range *A-2* missiles and 28 with 2,500-mile-range *A-3* missiles. It is also planned to put the *A-3* aboard four more *A-2* boats during overhaul in FY'68-69. Twenty-nine SSBN's are now operational.

Engineering development will be accelerated on the $1.3-billion *Poseidon* development program, but DOD officials say no decision has been made on the number of subs to be retrofitted. FY'67 funding will be $300 million.

An additional $10 million is included for the Air Force to continue studies of an advanced ICBM beyond *Minuteman III*, and $3 million for the Navy for study of improved propulsion systems for advanced sea-based missiles.

SRAM funds up—Funding for development of the *Short-Range Attack Missile (SRAM)* to be carried aboard the B-111 will be increased from $8 in FY'66 to $40 million next year. Total cost to completion of development is now estimated at $170 million.

The system is not now intended for use with the B-52 G and H bombers that will be kept in service, but funds are being asked to develop the avionics, should this mating be necessary.

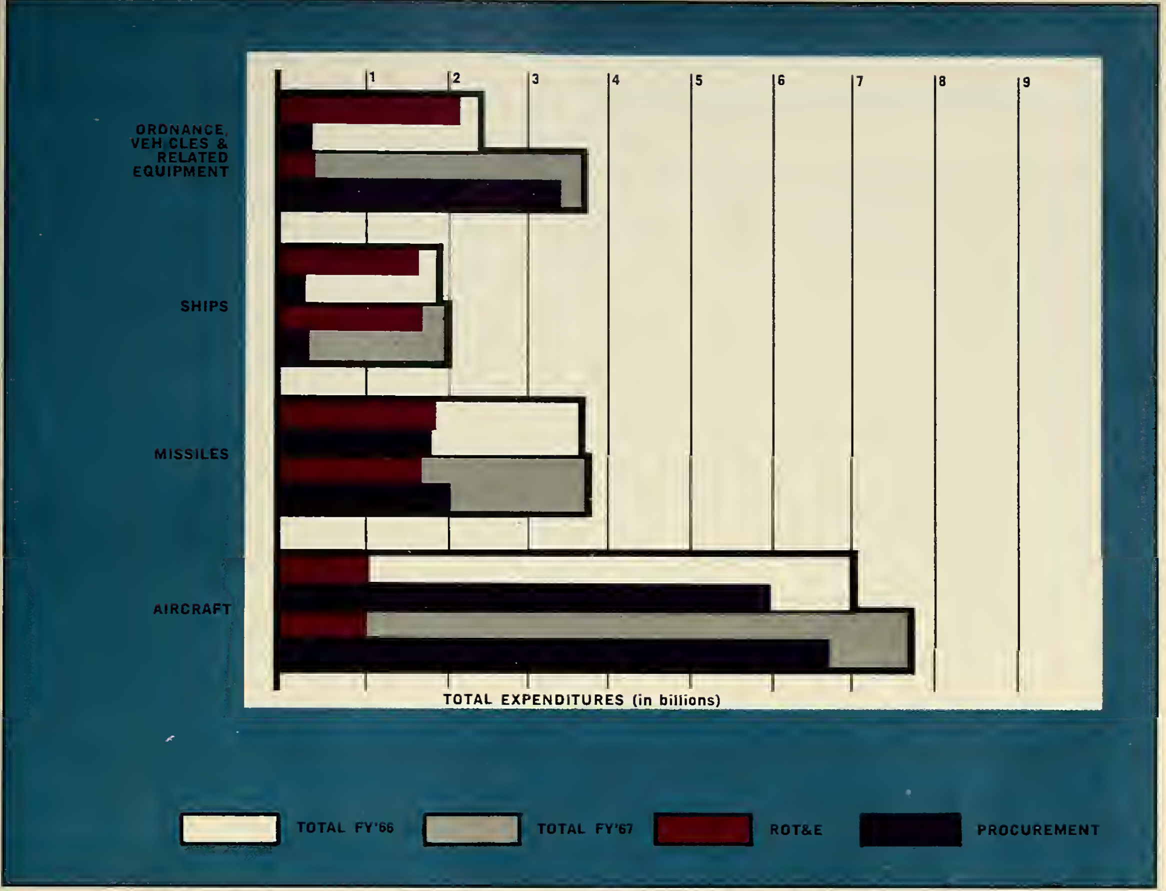
SRAM has also been mentioned in recent Congressional hearings as a candidate for use aboard the Army's new Advanced Aerial Fire Support System (AAFSS).

Another $8.1 million is included in the budget to add a new terminal guidance system to the B-52-carried *Hound Dog* missile to improve reliability. Total engineering development cost is placed at $20.5 million.

FY'67 will also usher in expansion in development and production of several other continental air defense and tactical missile programs.

First full production of the Navy's new *Standard Missile* for shipboard air defense is requested. The system will work with the new *Tartar-D* integrated weapons control system (M/R, Oct. 25, p. 9) for which new development funds have been asked.

The Army's 70-km range *Lance* divisional support missile will also get initial procurement funds. Some Navy funds for shipboard evaluation are also included. Procurement of the Army's



Chaparral interim air defense missile system will be increased. Procurement will continue for a host of other already developed ground- and ship-based missiles (see p. 28).

FY'67 will also see an assortment of new tactical air-to-surface missiles move into the development phase.

The Air Force's *Maverick,* a TV-guided standoff missile (M/R, Dec. 6, p. 14) will move into the development stage, DOD officials told M/R. The Navy's *Condor* (M/R, Jan. 10, p. 9), another electro-optically guided long-range standoff missile, will also get FY'67 development funds, DOD officials report. Development is actually expected to start later this fiscal year.

The Navy's *ARM-1* anti-radiation missile is also expected to get initial development funding. The Navy will also put into development an advanced version of the *Sparrow III* air-to-air missile. Development funds are requested for both the Army's *TOW* anti-tank missile (M/R, Oct. 25, p. 14) and *MAW* medium-assault-weapon (M/R, Jan. 10, p. 15); however, no production funds are believed to be included in the budget.

SAM-D hiked—Army will move into full-scale development at an accelerated funding level in FY'67 with its new *SAM-D* air defense missile (M/R, Jan. 3, p. 12), with definition phase contracts expected early this year. *SAM-D* will have some limited capability against tactical missiles, project officials say.

Nike-X still cannot jump the hurdle of cost-effectiveness placed in its path by the top level of DOD. The system will continue as an R&D effort at a level slightly greater than last year's $400 million. Officials stress that the cost of a system to defend against a sophisticated ICBM threat is still out of proportion to the benefits.

Its use against a so-called Nth country threat, such as China, is not yet dictated because the lead times are greater for the offense in this case than the defense. DOD officials emphasize the need for a balanced defense against bombers, ballistic missiles, and sub-launched missile forces, and do not want to be dollar-shy in any one area because of the high costs of marginal ICBM protection.

Funds are apparently included in the FY'67 budget for some defense against submarine-launched cruise-type missiles, which pose an earlier threat to the U.S. in the hands of the Chinese than does the ballistic missile (M/R, Jan. 17, p. 9).

Penetration aid efforts will also be accelerated in FY'67, with particular emphasis on developing devices needed to defeat an area A-ICBM defense employing exo-atmospheric missiles. DOD has spent about $1.2 billion in the penaids area thus far.

To aid in ballistic missile detection and warning, funds are included to complete the initial Sea-Launched Ballistic Missile warning system (M/R, Jan. 24, p. 16), for first operational installation of over-the-horizon radar, and for improved space-based detection of missile launchings.

Funds are also included to improve anti-satellite detection and interception systems.

Ships—Navy will add two new guided-missile destroyers housing the *Tartar-D* weapons system with FY'67 funds. Other anti-air warfare ship construction includes the modernization of five frigates and one cruiser.

RESEARCH, DEVELOPMENT, TEST, AND EVALUATION FY 1966-1967

(Millions of Dollars)

FUNCTIONAL CLASSIFICATION	DIRECT BUDGET PLAN (TOA)		NEW OBLIGATIONAL AUTHORITY		EXPENDITURES	
	FY 1966	FY 1967	FY 1966	FY 1967	FY 1966	FY 1967
MILITARY SCIENCES						
Army	160	162	156	162	147	152
Navy	186	192	181	192	183	185
Air Force	159	164	158	164	143	152
Defense Agencies/OSD	103	107	103	107	98	104
Total	608	**625**	598	**625**	572	**592**
AIRCRAFT						
Army	105	93	100	93	90	86
Navy	286	246	276	246	231	245
Air Force	796	678	720	678	758	691
Defense Agencies/OSD	17	12	7	12	16	11
Total	1,205	**1,028**	1,103	**1,028**	1,094	**1,034**
MISSILES						
Army	681	719	646	719	636	674
Navy	398	665	389	665	394	488
Air Force	799	830	788	830	712	788
Defense Agencies/OSD	120	119	120	119	114	113
Total	1,998	**2,334**	1,942	**2,334**	1,855	**2,063**
ASTRONAUTICS						
Army	23	13	2	13	22	13
Navy	21	13	24	13	—	16
Air Force	988	814	987	814	932	803
Defense Agencies/OSD	4	4	4	4	3	3
Total	1,036	**843**	1,017	**843**	981	**835**
SHIPS						
Army	2	1	2	1	1	—
Navy	330	281	348	281	281	309
Total	331	**282**	350	**282**	282	**309**
ORDNANCE, VEHICLES, AND RELATED EQUIPMENT						
Army	201	187	190	187	188	175
Navy	190	178	184	178	152	171
Defense Agencies/OSD	1	2	1	2	1	1
Total	393	**367**	376	**367**	340	**347**
OTHER EQUIPMENT						
Army	258	267	291	267	243	261
Navy	80	87	88	87	69	76
Air Force	312	289	303	289	315	284
Defense Agencies/OSD	243	214	246	205	228	207
Total	893	**857**	928	**848**	855	**829**
PROGRAMWIDE MANAGEMENT AND SUPPORT						
Army	74	78	75	78	73	74
Navy	78	86	76	86	68	75
Air Force	301	278	297	278	240	222
Defense Agencies/OSD	11	11	11	11	10	10
Total	464	**453**	458	**453**	391	**381**
EMERGENCY FUND—Defense Agencies/OSD	19	**125**	19	**125**	—	**10**
TOTAL—RESEARCH, DEVELOPMENT, TEST, AND EVAL.						
Army	1,504	1,519	1,462	1,519	1,400	1,435
Navy	1,569	1,749	1,566	1,749	1,400	1,565
Air Force	3,355	3,054	3,253	3,054	3,100	2,940
Defense Agencies/OSD	518	593	511	584	470	460
Total	6,946	**6,914**	6,791	**6,905**	6,370	**6,400**

Heavy emphasis on anti-submarine warfare, partly as a key to defense against sub-launched missiles, includes construction or modification of 20 ASW vessels. New construction includes five new nuclear-powered attack submarines, carrying the *SUBROC* missile, and 10 destroyer escorts. Five destroyers will be converted.

The Navy will also get its second nuclear-powered aircraft carrier, this one to be the first with a two-reactor propulsion system.

Aircraft—Key items in the estimated $6.7 billion to be spent for aircraft procurement in FY'67 include large-scale purchase of the F-111A for the Air Force, and inclusion of $202 million for continued development and initial procurement of the FB-111A dual-purpose (strategic and tactical) bomber.

No mention whatever of the F-111B, the Navy version of the TFX, is found anywhere in the FY'67 budget. The B-111 program is expected to involve a total investment cost of $1.9 billion to procure the entire 210 aircraft planned.

Funds are also provided for an initial Air Force buy of the Navy-developed A7A attack aircraft, for additional procurement of the F-4 aircraft, and for initial procurement of the C-5A transport. FY'67 funds will also complete procurement of the C-141 transport, bringing the full 14 squadrons (224 aircraft) into operation.

It was also announced that a new counter-insurgency aircraft for Navy, Air Force, and Marine Corps use would be procured in FY'67, but that selection of the contractor had not yet been made.

Helicopter production will account for a large portion of the total aircraft spending. Included are funds for the engineering development of AAFSS by the Army. The Army will procure 1,496 helicopters, mostly UH-1B and CH-47 craft, and about six more CH-54 flying cranes.

The Navy will get 144 new helicopters and the Air Force 33. DOD officials say there is no plan to develop an interim armed helicopter between the UH-1B and the AAFSS.

Construction—Included within the new military construction program request are Army funds for additional *Nike-X* construction at various Pacific island radar and missile sites, *MOL* construction at Vandenberg AFB, additional silo construction for the *Minuteman* force and "for increasing the reliability and survivability of ballistic missile facilities." The Navy is also requesting construction funds for new missile development facilities at Patrick AFB, Fla. ■

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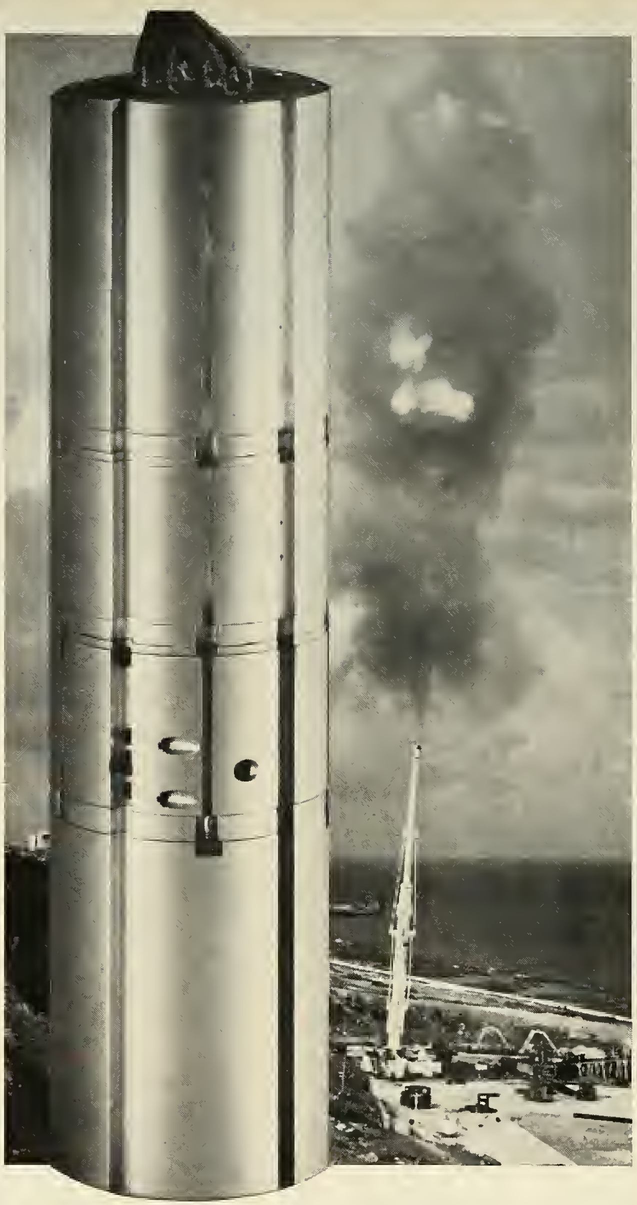

At Computing Devices' Space Sciences Division, solid state telemetry systems, such as the one above are created to withstand accelerations of more than 50,000 g. These consist of a power supply, inertia switch, voltage regulator, voltage-controlled oscillators, a commutator and a 215-260 Mc, F.M. transmitter. ☐ Developments of the Space Sciences Division include high g telemetry systems for aeroballistic ranges, gun-launched upper-atmosphere research vehicles, high acceleration rockets and missiles and hard-landing instrumentation. For information, please write Space Sciences Marketing Manager at address below. ☐ *If you are looking for a career in the exciting, expanding world of aerospace sciences, opportunities are open in these areas :— aerodynamics, ballistics, impact physics, gas dynamics, thermodynamics, solid state physics as well as mathematics, physics and engineering. Inquiries from qualified applicants should be sent in confidence to the Director, Industrial Relations and should refer to File No. 3810.*

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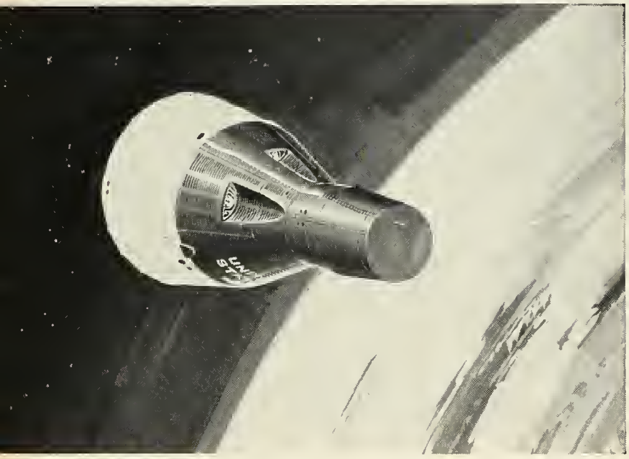
BEECH "IMAGINUITY" AT WORK:

U S AIR FORCE

For Lockheed, Beech builds several wing sections, nose landing gear doors and emergency exit doors for the huge new U. S. Air Force C-141A "StarLifter" turbofan jet transport. This massive military cargo aircraft has speeds up to 550 mph.

For McDonnell, Beech builds wing sections, flaps, ailerons, speed brakes, spoilers, landing gear doors and nose gear doors for the 1,500 mph Navy/USAF "Phantom II" jet fighter, considered one of the most versatile fighter-bomber-interceptors ever built.



For NASA's Project Gemini, Beech was chosen by McDonnell to design, develop and build the ground support equipment that supplies liquid hydrogen and liquid oxygen for the reactant supply system and the environmental control system aboard the Gemini spacecraft. Beech equipment is used at 11 vital points.

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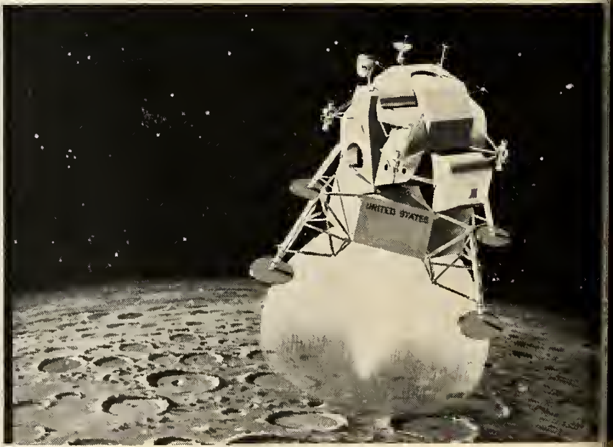
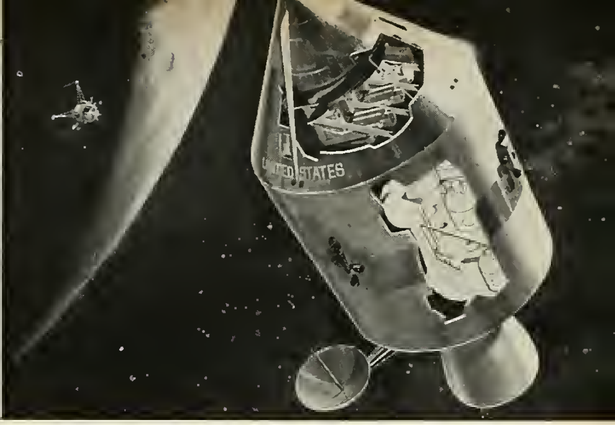
U.S. AIR FORCE
FH-743

The U. S. Air Force F-105 "Thunderchief" jet fighter-bomber, which can deliver weapons at twice the speed of sound, flies on Beech-built ailerons and aft fuselage assemblies. Beech has built major components for virtually every Century-series fighter.



For the LEM, Grumman selected Beech to assure complete systems responsibility for the design, development, fabrication, and testing of equipment required for storage, transfer, and loading of liquid helium—used aboard LEM to pressurize propellant tanks to assure proper flow in weightless environment.

For Bell, Beech builds metal bonded fuselage panels which contribute to the exceptional structural strength of the U. S. Air Army HU-1D "Iroquois" jet-powered helicopter. One of the fastest and most effective rotary-winged aircraft in our military services, the "Iroquois" also has Air Force and Marine use.



Chosen by North American to develop and build the Cryogenic Storage Subsystem to supply "shirtsleeves" atmosphere to the astronauts and generate electrical power for the Apollo command module. A cryogenics pioneer, Beech has made vital contributions in weight reduction and mission duration for space vehicles.

On these pages are just a few examples of how Beech's broad range of capabilities help many of America's leading prime contractors fulfill their responsibilities for vital military and aerospace projects.

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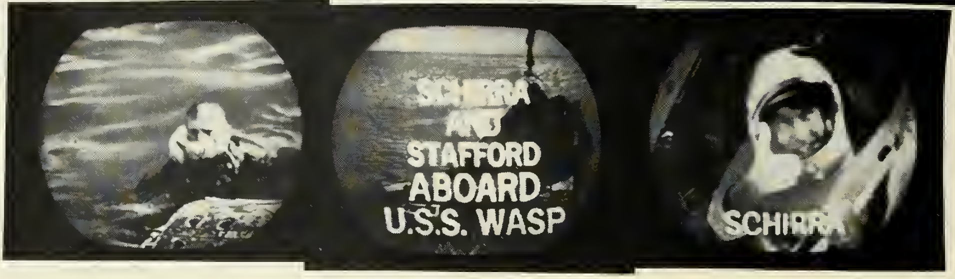
GEMINI 7



Coverage of the Gemini 6 and 7 astronauts' successful return to Earth marked a historic TV "first"—live action televised far out at sea. The events were beamed instantly to millions of North Americans and Europeans.

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NASA Cutback Perils Moon Schedule

Total of $5.012 billion approved by Administration for FY '67; Seamans sees chance for landing by '70—if no major problems develop

REQUIREMENTS of Vietnam and the Great Society have pared NASA's Fiscal Year 1967 budget request to $5.012 billion, putting in jeopardy the U.S. goal of landing a man on the Moon by the end of this decade and putting off approval of a follow-on manned flight program for another year.

The Johnson Administration-approved NASA budget also marks the first time in eight years that the space agency request for new programs was less than in the previous year.

Next year's budget request is $250 million below the $5.26 billion requested in new authorizations in FY '66 and over $150 million below the $5.174-billion total which was approved by Congress.

The 1967 request includes $4.246 billion for research and development, $101.5 million for new construction and $663.6 million for administrative operations.

In terms of money that will actually be spent, total expenditures next year will drop to $5.3 billion, $300 million below the $5.6 billion expected to be spent in the current fiscal year.

The expenditure total includes $4.340 billion in research and development, $300 million in construction and $660 million in administrative operations.

Besides taking any possible latitude out of the Project *Apollo* schedule, the reduced budget for next year—which compares to $5.58 billion NASA wanted—has funds for only two new programs. The 1967 *Mariner* mission to Venus and the 1969 flights to Mars will be funded at a level of $26.1 million and the *Apollo* Applications Program will receive funding in the neighborhood of $100 million. Dr. Robert C. Seamans, Jr., deputy NASA administrator, pointed out, however, that the agency has decided not to seek Congressional approval of AAP flights for another year.

No provision for trouble—In discussing the reduction in NASA's desired budget of $5.58 billion, Seamans said the approved figure clearly increased the risk of landing a man on the Moon before 1970.

"This budget was reviewed with the President at this level on the basis that we would be able to carry out the lunar mission in this decade. However, we made it very clear at the time we reviewed it that we do not have the funds in here that the program and center people would like to see; that we have in here a program that we are willing to work towards; that we believe it does give us a chance of a lunar landing in this decade; but there is absolutely no funding to take care of major difficulties that might be incurred," the NASA official said.

He said that the lowest budget proposed for NASA by the Johnson Administration was $4.8 billion, but NASA's position was that that figure would not have enabled this country to achieve the manned lunar landing.

Queried later as to whether he meant the U.S. is within $200 million of missing its Moon target, he declared that he believed the figure was less than that.

Manned Spaceflight—The manned spaceflight budget request dropped to $3,022,800,000, almost $200 million below last year's request of $3,203,996,000.

Most of the reduction was absorbed by the sharp drop in requirements for Project *Gemini*, the two-man spaceflight series which is nearing its end. With only three flights remaining to be made in the next fiscal year, the total budget dropped from $226.6 million in the current year to only $40.6 million requested for next year. That figure includes $19.1 million for the spacecraft and $8.5 million for mission suport.

Funding for Project *Apollo* is scheduled to increase slightly—from $2.967 billion to $2.974 billion, including $1.2 billion for the spacecraft (up slightly from this year's $1.17-billion level).

Funding for *Saturn IB* dropped from $274.1 million to $216.4 million. Money for *Saturn V* will increase slightly—from $1.17 billion to $1.19 billion.

Development costs of the liquid kerosene/liquid oxygen F-1 engine and the J-2 liquid hydrogen/liquid oxygen engine will drop from $134 million to $111 million.

Apollo mission support funding request will increase slightly from $210.3 million to $255.2 million.

This includes $42 million which will be set aside for the *Apollo* Applications Program. In addition, another $25 million set aside in the manned lunar science budget in the Office of Space Sciences and Applications will be used to fund the systems definition and hardware development of AAP experiments.

Seamans estimated that the total available for AAP in the next fiscal year is about $100 million. He said that some of that funding would be obtained by delaying the spending of money which is authorized for the program in fiscal 1966.

Seamans said that the agency had originally asked the Bureau of the Budget to approve a $200-million funding request for AAP. With the $100 million available in 1967 and the funding available in 1966, he said, NASA would move into systems definition in the current fiscal year and use next year's funds to complete the definition phase as well as fund some experiment and long-lead-time items for future AAP systems.

No gap expected—He said that the decision to go ahead with the program will now not be made until the FY '68 budget discussions. He denied, however, that the one-year delay would leave a gap in the U.S. manned spaceflight program.

"If we go ahead in '68 we will be able to continue with flights that will proceed in sequence following the present *Apollo* program, but we will not have as extensive experiments for these flights, or we will have to take some gap in the rate in order to have additional experiments. We will not have the option to go ahead in all the areas where it is technically feasible. . . ."

It is known that the funding level for AAP was largely responsible for some of the early press reports which placed the space agency's budget at the $5.175 billion level.

Seamans declared, however, that the $5.012-billion level was fixed during a meeting between President Johnson and NASA Administrator James E. Webb in December.

It is known that NASA enlisted the support of top Congressional leaders in an effort to get the Budget Bureau to approve the additional $100 million it wanted for AAP. If the agency had been successful, it would have put the final budget at over the $5.1 billion level.

Space Sciences and Applications—The Office of Space Sciences and Applications also received a heavy blow from the budget cutters, who trimmed the 1967 request to $661.4 million—over $200 million below last year's $783.2-million total.

The reduction was absorbed by almost every area of the office's various divisions—including physics and astronomy, down from $143.5 million to $131.4 million; lunar and planetary exploration, from $251.3 million to $197.9 million; the sustaining university program, from $46 million to $41 million; launch vehicle development, from $55.3 million to $33.7 million; launch vehicle procurement, from $178.7 million to $152 million; bioscience from $36.7 million to $35.4 million; and communication and application technology satellites, from $32.8 million to $26.4 million.

Only meteorological satellites showed an increase—rising from $38.9 million to $43.6 million primarily because of the increase in funding for the *Nimbus* series, which rose from $20 million to $23.4 million, and a rise in meteorological flight experiments from $3.9 million to $5.5 million.

The sharp drop in lunar and planetary funding stems primarily from the decision to delay the *Voyager* program for at least one year.

Originally scheduled to receive $150 million in Fiscal 1967, the Mars exploration program's budget was trimmed to only $10 million with the decision to delay the first flight until 1973.

The budget saving from the *Voyager* delay is partially offset by increased funding for the *Mariner* program, which will send spacecraft hurtling toward Venus in 1967 and Mars in 1969.

Estimates for that program call for a total price for the Venus flights of $30 million and a total of $100 million for two trips to Mars.

Of the $26 million requested in FY '67, $12 million will be earmarked for the 1967 Venus mission and $13 million for the 1969 Mars flights. The space agency's budget for the current year provides $9 million for the Venus flight and $6 million for the Mars flights.

Boosters—In discussing the decrease in launch vehicle procurement, the NASA deputy administrator said that the *Scout* booster will continue to be launched from the Western Test Range as well as Wallops Is. The schedule now calls for 3 launches in 1966 and eight in 1967.

The *Delta* will also soon have a Western Test Range launch capability, with a total of six launches planned in 1966 and nine in Fiscal 1967.

Schedules for the other major vehicles call for seven *Agena* launches in 1966 and 11 in 1967. Four launches per year are planned for the *Centaur* in the same period.

Procurement requests for the launch vehicles included $10.4 million for *Scout*, $22.9 million for *Delta*, $54.7 million for *Agena* and $64 million for *Centaur*. Costs of the first-stage *Atlas* boosters used in *Agena* and *Centaur* launches are included in the budget requests for the upper stages.

Observatories—In the physics and astronomy area, there was a sharp drop in funding for solar observatories, primarily because of the cancelation of the advanced observatory series.

Seamans said NASA would continue to launch the solar observatories in 1968 and 1969 and currently is working on equipments which might be flown on *Apollo* flights.

In the astronomical area, which increased from $24.6 million to $29.2 million, one will be launched this year, two in Fiscal 1967 and one each in 1968 and 1969.

In the geophysical observatory area, which dropped from $29.6 million to $23.4 million, the launch schedule calls for one in 1966, two in 1967 and one in 1968.

The $19-million request for sounding rockets calls for about 150 launches in the fiscal year.

Seamans also announced some changes in the *Surveyor* program—where the budget will drop from $110 million to the $90-million level. He said that the first seven spacecraft would be engineering models designed simply to take pictures of the lunar surface. These are being developed by the Hughes Aircraft Co.

U.S. SPACE PROGRAM
(in millions)

	NOA		EXPENDITURES	
	FY '66	FY '67	FY '66	FY '67
NASA	5,175	5,012	5,600	5,300
DOD	1,690	1,621	1,640	1,650
AEC	196.0	173.5	201.0	174.0
WEATHER BUREAU	27.0	34.0	19.2	27.0
NATIONAL SCIENCE FOUNDATION	3,6	3.0	3.5	3.0
TOTAL	7,091.6	6,843.5	7,385	7,065

Three more spacecraft—bringing the total in the program to ten—will be heavy 2,500 lb. spacecraft to be developed by Jet Propulsion Laboratory.

The space agency's sustaining university program reductions included $3 million in training, $1 million in research, and $1 million in facilities. The total request dropped $5 million to $41 million.

Tracking up—The NASA office showing the largest increase is the Office of Tracking and Data Acquisition, which jumped from $231 million in Fiscal 1966 to $279.3 million in 1967.

Seamans said that the increase was caused by funding needed to put the manned space network, uprated for *Apollo*, into operation including the use of three injection and insertion ships as well as two re-entry tracking ships.

Funding will also start on the *Apollo* instrumentation communications satellite.

In discussing the *Apollo* communication satellite requirements before a House Military Operations subcommittee last week, the deputy administrator estimated that the system would cost at least $100 million over the next ten years.

He said the total included an estimated $80 million which would go to the Communications Satellite Corp. and $22.5 million for equipment in support of the satellite communications system on board the *Apollo* tracking ships.

The NASA office which received the smallest reduction in funding is the office of Advanced Research and Technology. Its Fiscal 1967 request totals $278.3 million, only about $10 million below the $288-million authorization in the current fiscal year.

Engines—One major trend is the initiation of the NERVA engine development program in Fiscal 1967, based on the Phoebus graphite reactor which will provide a thrust of 250,000 lbs.

The funding request for the engine totals $33.1 million in the next fiscal year, with another $16.9 million requested for supporting research and technology.

Funding for chemical propulsion systems will drop slightly—from $39.7 million to $37 million—with $33.5 million slated for supporting research and technology studies.

Two major chemical programs received harsh treatment at the hands of the budget-makers. The M-1 engine project was cancelled completely and the funding request for the large solid motor program totals only $3.5 million, just enough to pay for one more half-length firing of the 260-in.-dia. motor. Under next year's budget, the program will be phased out and there will be no firing of a full-length motor.

Seamans said that the space agency would spend close to $100 million on aeronautical programs in Fiscal '67, including $33 million for research and development, $21 million in new facilities including a new hypersonic propulsion facility at the Lewis Research Center, and administrative operations at Lewis, the Langley Research Center, the Ames Research Center and the Flight Research Center totaling $39.5 million. He said an additional $30 million in advanced research and technology studies is also aimed at the aeronautical area.

Construction—The total NASA request for construction funds is $101.5 million, well above last year's request.

Over one-third of the request, $37.87 million, will be spent at the John F. Kennedy Space Center, primarily to pay for completion of launch complex 39, which is expected to cost

$29.5 million. Other construction items at the center include modifications to the *Thor-Delta* launch complex 17, $740,000; modification to *Atlas-Agena* launch complex 12, $639,000; extension to Central Supply Complex, $600,000; addition to the headquarters building, $3.5 million; and new utility installation in the Merritt Island Launch Area, $2.89 million.

A breakdown in construction at the agency's other center's follows:

—*Goddard Space Flight Center*—a total of $710,000 for the 40-ft. Antenna Test Bed.

—*Jet Propulsion Laboratory*—a total of $350,000 for a utilities installation.

—*Electronics Research Center*—a total of $10 million including $4.95 million for the Space Guidance/Optical Communications Special Purpose Laboratory, $3.04 million for the Qualifications and Standards Electronics Components Special Laboratory, and $2 million for center support activities.

—*Langley Research Center*—a total of $6.1 million including $1.08 million for the reactive chemical distribution area, and $5.01 million for the V/STOL Transition Research Wind Tunnel.

—*Lewis Research Center*—a total of $16 million including $14 million for expansion of Propulsion System Laboratory for supersonic research (Cleveland), and $2 million for installation of equipment at the Hydrogen Heat Transfer Facility for hypersonic propulsion research (Plum Brook).

—*Manned Spacecraft Center*—a total of $13.8 million including $9.1 million for Lunar Sample Receiving Laboratory, $1.1 million for flight crew training facility, $2.6 million for engineering building, and $1 million for center support facilities.

—*Marshall Space Flight Center*—a total of $581,000 for the hazardous operations laboratory addition.

—*Michoud Assembly Facility*—a total of $700,000 for modification of the chemical waste disposal system.

—*Mississippi Test Facility*—a total of $1.7 million for facilities to support S-IC and S-II test program.

—*Wallops Station*—a total of $205,000 for rocket storage magazine.

—*Various locations*—a total of $6.478 million including $1.1 million for facilities for S-IVB stage program, Sacramento, Calif., $2.443 million for Launch Vehicle Service Tower, Western Test Range, Calif., $1.2 million for *Aerobee 350* launch facility, White Sands, N.M., $745,000 for Spin Test Facility, Western Test Range, Calif., and $990,000 for water distribution and sewage disposal systems, Goldstone, Calif.

Requirements for facility planning and design are set at $7 million. ■

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT PROGRAMS

(In thousands of dollars)

	FY 1965	FY 1966	FY 1967
MANNED SPACE FLIGHT	2,949,019	3,203,996	3,022,800
Gemini	308,400	226,611	40,600
Apollo	2,614,619	2,967,385	2,974,200
Advanced mission studies	26,000	10,000	8,000
SPACE SCIENCE AND APPLICATIONS	732,362	783,237	661,400
Physics and astronomy	139,082	143,500	131,400
Lunar and planetary exploration	206,027	251,337	197,900
Sustaining university program	46,000	46,000	41,000
Launch vehicle development	96,500	55,300	33,700
Launch vehicle procurement	154,487	178,700	152,000
Bioscience	28,501	36,700	35,400
Meteorological satellites	30,991	38,900	43,600
Communication and applications technology satellites	30,774	32,800	26,400
ADVANCED RESEARCH AND TECHNOLOGY	331,328	288,596	278,300
Basic research	21,231	22,000	23,000
Space vehicle systems	44,193	35,000	36,000
Electronics systems	25,622	32,300	36,800
Human factor systems	13,320	14,900	17,000
Space power and electric propulsion systems	58,220	45,200	42,500
Nuclear rockets	57,000	58,000	53,000
Chemical propulsion	76,502	39,700	37,000
Aeronautics	35,240	41,496	33,000
TRACKING AND DATA ACQUISITION	253,236	231,065	279,300
TECHNOLOGY UTILIZATION	4,750	4,750	4,800
TOTAL	4,270,695	4,511,644	4,246,600

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

INSTALLATIONS	(In thousands of dollars)		
MANNED SPACE FLIGHT	FY 1965	FY 1966	FY 1967
John F. Kennedy Space Center, NASA	88,618	7,782	37,876
Manned Spacecraft Center	23,907	4,180	13,800
Marshall Space Flight Center	12,454	2,309	581
Michoud Assembly Facility	6,450	285	700
Mississippi Test Facility	58,891	1,910	1,700
SPACE SCIENCE AND APPLICATIONS			
Goddard Space Flight Center	2,314	2,400	710
Jet Propulsion Laboratory	3,582	—	350
Wallops Station	1,699	1,048	205
ADVANCED RESEARCH AND TECHNOLOGY			
Ames Research Center	5,668	2,749	—
Electronics Research Center	10,000	5,000	10,000
Langley Research Center	3,640	8,250	6,100
Lewis Research Center	770	867	16,000
Various Locations	33,114	20,183	6,478
Facility Planning and Design	10,000	2,624	7,000
TOTAL	261,107	59,587	101,500

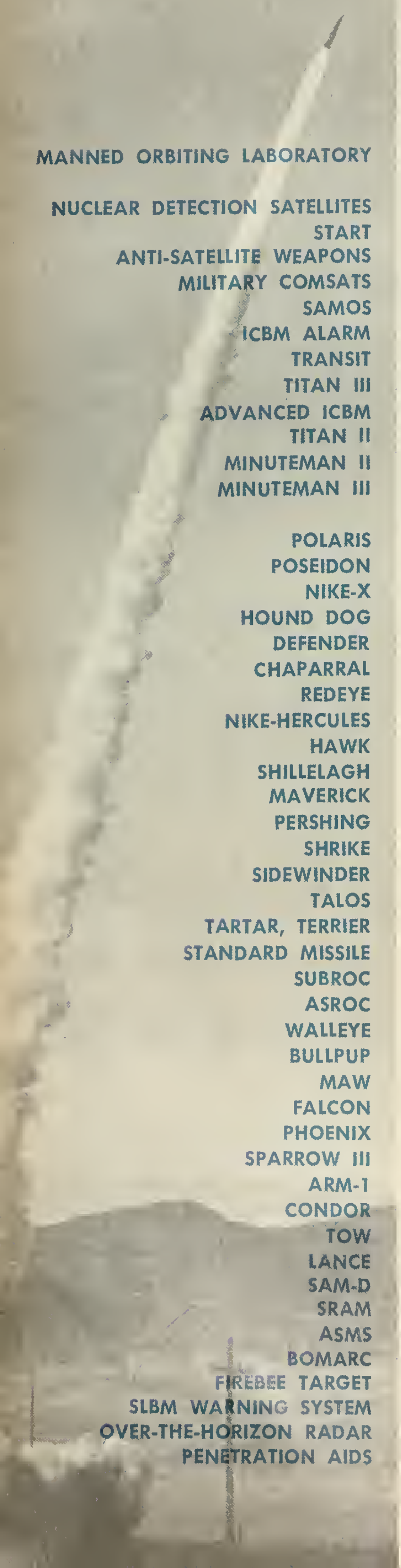
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ADMINISTRATIVE OPERATIONS BY INSTALLATION

(In thousands of dollars)

MANNED SPACE FLIGHT	FY 1965	FY 1966	FY 1967
John F. Kennedy Space Center, NASA	53,260	79,723	98,108
Manned Spacecraft Center	91,036	87,550	98,212
Marshall Space Flight Center	137,787	128,260	131,934
SPACE SCIENCE AND APPLICATIONS			
Goddard Space Flight Center	92,570	64,040	71,687
Wallops Station	10,931	9,446	10,166
ADVANCED RESEARCH AND TECHNOLOGY			
Ames Research Center	31,807	32,923	33,475
Electronics Research Center	3,201	6,233	15,143
Flight Research Center	10,523	9,335	9,641
Langley Research Center	58,998	63,006	62,587
Lewis Research Center	68,546	67,207	66,284
Space Nuclear Propulsion Office	1,669	1,824	1,847
SUPPORTING OPERATIONS			
Western Operations Office	22,693	5,987	6,149
NASA Headquarters	51,516	56,286	58,667
TOTAL	634,537	611,820	663,900

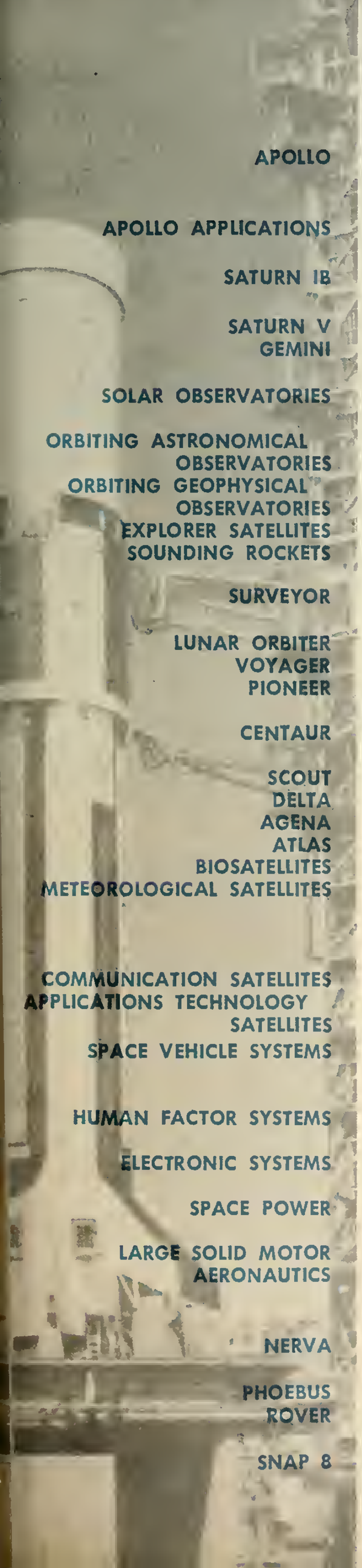
FISCAL '67 BUDGE



DEFENSE

MANNED ORBITING LABORATORY	FY '67 funds of $150 million for development are far below original plan; stretchou likely; new construction funds provided for Vandenberg AFB.
NUCLEAR DETECTION SATELLITES	Work on improved satellites to continue.
START	Development of re-entry technology continues.
ANTI-SATELLITE WEAPONS	New funds for improved tracking, photography and interception.
MILITARY COMSATS	Funds for IDCSP replenishment launch and for advanced system R&D.
SAMOS	Program continues; new emphasis on capsule recovery techniques.
ICBM ALARM	New funds for space-based missile early warning development.
TRANSIT	Program continues; funds for advanced navsat development.
TITAN III	Flight program continues, but funding for R&D declines.
ADVANCED ICBM	$10 million for AF and $3 million for Navy for FY '67 studies.
TITAN II	Procurement continues for follow-on operational test program.
MINUTEMAN II	Funds to add four 50-missile squadrons to bring total force to 1,000 in FY '67.
MINUTEMAN III	Advanced version with new re-entry vehicle probably containing multiple warhead and with some maneuverability; funds for R&D and initial procurement.
POLARIS	Stepped-up buy of A-3 to complete 41-submarine fleet in FY '67 with A-2, A-3 mix
POSEIDON	Greatly expanded development in FY '67; $300 million in new funds.
NIKE-X	Still in R&D, but above $400 million FY '66 level.
HOUND DOG	$8.1 million for new terminal guidance system.
DEFENDER	A-ICBM research to continue at $125 million annually.
CHAPARRAL	Procurement increases in FY '67.
REDEYE	Procurement for Army and Marines continues.
NIKE-HERCULES	New funds for modification for improved CONUS defense.
HAWK	New funds for improvements in mobility and anti-tactical missile performance.
SHILLELAGH	Procurement continues.
MAVERICK	Development funding for new air-to-surface tactical missile begins in FY '67.
PERSHING	More funds for modification program to improve reliability and rate-of-fire.
SHRIKE	AF/Navy to buy improved version in FY '67.
SIDEWINDER	Navy procurement continues, also for Chaparral.
TALOS	Procurement continues.
TARTAR, TERRIER	Funds for support items.
STANDARD MISSILE	First production money for new missile; used with Tartar-D control system.
SUBROC	Procurement continues.
ASROC	Procurement continues.
WALLEYE	Navy production; AF buy likely.
BULLPUP	AF procurement of B version; no Navy buy.
MAW	Development to continue; no procurement yet.
FALCON	AF to buy trainer version; some development on AIM-47A for YF-12A aircraft.
PHOENIX	Development continues, but no procurement in FY '67.
SPARROW III	Advanced version to be developed by Navy; AF procurement continues.
ARM-1	Funds set aside for FY '67 development.
CONDOR	Development to begin in late FY '66 and continue in FY '67.
TOW	Development continues of anti-tank missile; no procurement expected until FY '68.
LANCE	Initial procurement planned; some Navy use likely aboard ship.
SAM-D	Substantial increase in development funding.
SRAM	Development funding increases to $40 million; procurement likely in FY '68.
ASMS	Development continues; closely linked to Army's SAM-D progress.
BOMARC	Six squadrons remain active.
FIREBEE TARGET	Procurement continues for AF.
SLBM WARNING SYSTEM	Funds to put first interim system into use.
OVER-THE-HORIZON RADAR	Funds for first fully operational systems.
PENETRATION AIDS	Development accelerated; emphasis on defeating exo-atmospheric ABM system.

PROGRAMS AT A GLANCE



NASA AND OTHERS

APOLLO	Total funding rises slightly from $2.967 billion to $2.974 billion: $1.2 billion for spacecraft, $111 million for engine development and $255.2 million for mission support.
APOLLO APPLICATIONS	Congressional approval of flights delayed one year. About $100 million requested for systems definition, experiments and procurement of long-leadtime items.
SATURN IB	Request drops from $274.1 million to $216.4 million as R&D cost curve moves downward.
SATURN V	Rises from $1.177 billion to $1.191 billion.
GEMINI	Funding drops sharply $226.6 million to $40.6 million with only three flights scheduled in FY '67.
SOLAR OBSERVATORIES	Request drops sharply from $24.5 to $11.9 million as Advanced Orbiting Solar Observatory program is cancelled.
ORBITING ASTRONOMICAL OBSERVATORIES	Funding rises slightly from $24.6 million to $29.2 million.
ORBITING GEOPHYSICAL OBSERVATORIES	FY '67 request decreases from $28.6 million to $23.4 million.
EXPLORER SATELLITES	Increase from $21.4 million to $23 million.
SOUNDING ROCKETS	Funding at $19 million compared to $18.5 million last year. About 150 launches scheduled.
SURVEYOR	Request drops from $111.6 million to $90.4 million as program is reduced to 10 approved spacecraft.
LUNAR ORBITER	Request of $24.6 million far below last year's $52.4 million funding.
VOYAGER	Request drops from $17 million to $10 million as first launch is delayed until 1973.
PIONEER	Request drops sharply from $12.7 million to $6.7 million with no development of advanced spacecraft approved.
CENTAUR	Sharp drop from $51.3 million to $29.7 million with the vehicle to be operational after three more launches. Procurement costs remain steady at $64 million.
SCOUT	Procurement drops from $11.7 million to $10.4 million.
DELTA	Procurement decreases from $27.9 million to $22.9 million.
AGENA	Procurement drops sharply from $71.1 million to $54.7 million.
ATLAS	Procurement cost included in Centaur, Agena procurement requests.
BIOSATELLITES	Decrease from $21.6 million to $20.7 million.
METEOROLOGICAL SATELLITES	Funding rises from $38.9 to $43.6 million: $23.4 million for Nimbus; $2.6 million for TIROS/TOS improvements; $5.5 million for meteorological flight experiments. Weather Bureau request $22.5 million for 3 TOS satellites, $6.3 million for command and data acquisition, and $3.8 million for data processing.
COMMUNICATION SATELLITES	Only $4.6 million requested for supporting research and technology studies.
APPLICATIONS TECHNOLOGY SATELLITES	Funding request drops from $28 million to $21.8 million.
SPACE VEHICLE SYSTEMS	Funding request remains almost level at $36 million: $28.7 million for supporting research and technology, $1 million for lifting body tests, $4.8 million for Scout re-entry tests and $1.5 million for small spaceflight experiments.
HUMAN FACTOR SYSTEMS	Request rises from $14.9 million to $17 million: $15.5 million for supporting research and $1.5 million for small biotechnology flight experiments.
ELECTRONIC SYSTEMS	Funding request rises to $36.8 million: $34 million for supporting research and $2.8 million for small flight projects.
SPACE POWER	Request drops slightly to $37 million for supporting research. No money requested for SERT flight tests.
LARGE SOLID MOTOR	Funding drops from $4.2 to $3.5 million with no full-length firing slated.
AERONAUTICS	Request drops from $41.49 million to $33 million: $900,000 for X-15, $14.1 million for supersonic transport, $2 million for hypersonic ramjet experiment and $2 million for XB-70 flight program.
NERVA	AEC requests $39.5 million compared to $42.5 million last year. NASA requests $33.1 million to continue engine development.
PHOEBUS	Request increases from $28 million to $29 million for reactor development.
ROVER	Funding drops from $84.4 million to $79.1 million as lack in KIWI funding is only partially offset by Phoebus and NERVA requests.
SNAP 8	NASA requests $5.5 million and AEC $5 million, but no flight test has been approved.

ATOMIC ENERGY COMMISSION SPACE RESEARCH AND DEVELOPMENT PROGRAM

OPERATING EXPENSES (IN THOUSANDS)

	FY 1965 Actual	FY 1966 Estimates	FY 1967 Estimates to Congress
SPACE PROPULSION SYSTEMS			
Reactor propulsion (Rover)			
KIWI project	$ 2,791	$ —	$ —
NERVA technology project	44,734	42,500	39,500
Advanced Rocket Reactor Technology			
Graphite reactors (Phoebus)	22,647	28,000	29,200
Tungsten reactors	3,446	3,200	—
Supporting technology	694	1,000	400
Nuclear Rocket Development Station			
Operations	9,364	9,400	9,400
Total Rover	83,676	84,100	78,500
Isotopic thruster technology (POODLE)	260	300	600
Total space propulsion systems	**83,936**	**84,400**	**79,100**
MISSILE PROPULSION REACTORS (PROJECT PLUTO)	3,249	—	—
SATELLITE AND SMALL POWER SOURCES (PROJECT SNAP)			
Space electric power systems			
Radioisotope power systems	3,300	11,515	14,250
SNAP 8	14,556	8,250	5,000
SNAP 10A	25,127	3,400	—
Other space electric power systems	34,746	25,510	20,600
Total space electric power systems	**77,729**	**48,675**	**39,850**
Advanced high-temperature gas reactor (710)	3,287	3,000	3,500
Aerospace nuclear safety	9,401	9,635	5,000

AEC

THE ATOMIC ENERGY COMMISSION spending request for space programs in the next fiscal year, which totals about $174 million, well below the current year's level of $201 million, provides no funds for flight tests of either SNAP or NERVA power units.

The drop in the space funding request mirrors the continuing decline in the overall AEC budget, which will total only $1.995 billion for Fiscal Year 1967, compared with the FY '66 estimate of $2.05 billion and the $2.25 billion spent in FY '65.

Largest items in the space budget are the *Rover* program, ticketed to receive $79.1 million, and Project SNAP (Satellite and Small Power Sources), which is earmarked for $39.85 million.

Two efforts, which have been completely phased out are the SNAP 10A tungsten reactor technology program and the Air Force's Project *Pluto*.

Funding will continue on SNAP 27, a 50-watt radioisotopic power system for the *Apollo* Lunar Surface Experiment Package (ALSEP), and a polonium 210 space generator which will provide several hundred electrical watts. About $4.5 million will be spent by the AEC on the project in Fiscal '67. It may also be used by NASA in its manned space flight program.

Phoebus up—The only major item in the *Rover* program to reflect an increase over the current fiscal year is the Phoebus graphite reactor, which will total $29.2 million compared with $28 million.

The funding request for the NERVA engine portion of the project continues to decrease, totalling $39.5 million compared with $42.5 this year and $44.7 million in FY '65.

Other funding requests for *Rover* include $400,000 for supporting technology, down sharply from last year's request of $1 million, $9.4 million for operations at the Nuclear Rocket Development Station, and $600,000 for Isotopic Thruster Technology in Project POODLE.

SNAP sags—Funding for SNAP systems continues to decline. Only $39.85 million is requested for next year, compared with $48.6 million in FY '66 and $77.7 million in FY '65.

Funding for radioisotopic power will increase from $11.5 million to $14.2 million primarily because of SNAP 27 requirements.

SNAP 8 funding dropped sharply from $8.250 million to $5 million with most of the funds earmarked for completion of a ground prototype.

For all other space electric power systems, $20.6 million is being requested, almost all for SNAP 50, which is being phased into a technology development effort.

Funding for isotopic power and heat-source fuels for both space and Earth uses will increase slightly—from $4.7 million to $6.5 million. As part of the program, AEC is asking for $3 million for an Alpha fuels-environmental test facility at the Mound Laboratory, Miamisburg, Ohio, to be used to develop and test radioisotopes for space.

Other major space requests include $3.5 million for an Advanced High-Temperature Gas Reactor and $5 million for Aerospace Nuclear Safety.

AEC is also asking for $10 million in new capital equipment directly attributable to the requirements of its space work and $5 million for plant expenses. The remainder of the space budget is included in the funding request for special nuclear materials (some of which are involved in the space effort) and the development of isotopes for space, according to an AEC spokesman.

In the field of terrestrial auxiliary power systems, the commission is requesting $700,000 for a low-power reactor technology program which may eventually be used in oceanography. ■

Weather Bureau

THE WEATHER BUREAU in Fiscal Year 1967 is asking for a total of $33.58 million in new obligational authority, the highest level in the past three years.

Next year's budget request compares with a total of $25 million in FY '66 and only $10 million in FY '65. The comparatively high figure reflects the dominant role which the Bureau now plays in U.S. operational meteorological satellite work and the desire to put its Data Analysis Satellite Center into full 24-hour operation.

Actual expenditures in the next fiscal year will also top those in the two previous fiscal periods. In FY '67, if Congressional approval is obtained, actual spending will reach $24.78 million, compared with $17 million in FY '66 and $21.8 million in FY '65.

Most of the expenditures will be used to pay for three new *TOS (Tiros Operational Satellites)*. A total of $22.5 million has been allocated for the satellites and it is expected that RCA will be named to build them as a sole-source selection.

The new satellites will combine the two camera systems now flown separately. These are the ATT direct readouts and the AVCS system, which will be able to store data gathered from a full orbit before it is transmitted back to Earth.

Name of the *TOS* satellite recently was formally changed to *ESSA (Environmental Science Services Administration) Satellite*. ESSA is the Dept. of Commerce Department office to which the Weather Bureau now reports.

Remainder of next year's expenditures will be used to pay for $6.3 million in command and data-acquisition equipment, which will provide a 24-hour operational capability, $3.8 million for in-house data-processing equipment, which will again extend the Bureau's operational capability in the area to 24 hours, and $1.1 million for technical management requirements.

In terms of new obligational authority, the Weather Bureau asked for $5 million for command and data-acquisition equipment, $3.39 million for data-processing equipment, $1.1 million for technical management, and $17 million for spacecraft and launch support. ■

Raytheon's Airborne Laser Rangefinder gives continuous target range for precise tactical weapons delivery.

Airborne strikes against small, tactical ground targets demand continuous and precise ranging information. To meet this need, Raytheon has developed and tested a Laser Rangefinder that provides a pulse repetition rate of up to 30 pps and a range accuracy of ± 5 m at 6 km. In addition, application of the laser to the delivery of unguided rockets and semi-active missile homing systems has been investigated.

The Airborne Laser Rangefinder model, currently in development, approximates 0.1 m^3 in volume and weighs under 22 kg. It utilizes an optically-pumped Nd^{3+} doped laser material to supply pulses with a beam divergence of only 0.5 milliradians. High pulse rate provides accurate ranging at high subsonic and supersonic closing speeds. During operation, average power consumption of the Airborne Rangefinder is 1.5 kw including power required by the cooling system. Range output information can be supplied in either analog or digital form as required by the bombing/navigation computer, autopilot or visual display.

For further information on the Airborne Rangefinder and its application in the tactical ground environment, please contact: *Manager, Marketing and Planning, Bedford Laboratories, Raytheon Company, Bedford, Massachusetts; Telephone: (617) 274-7100.*

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WHERE CAN MAN GO...IN ELECTRONICS

Electronics is a discipline unlike any other. For wha ever name we give to these fast paced times in which we live—the Age of Space, the Age of Mass Communications, the Age of Transportation—electronics plays a vital role. Through advances in this single key technology, advances in all others are brought nearer to reality. And nowhere is this truth more evident than at Lockheed, where to all programs, electronics is essential. Research. Development. Systems. At Lockheed, those knowledgeable in the nuances of electronics help to further man's achievement upon this planet. They bring practica ity to investigative ocean vehicles such as Lockheed's Deep Quest, a two-place research submarine. They permit land vehicles of the future to achieve reality. And they extend the reach of mankind heavenward through spacecraft systems such as Agena. Undersea, on land, and in space environments, Lockheed electronic systems control and guide, communicate and compute. Now, generalists and specialists, experienced and interested in a broad spectrum of electronics assignments, are invited to write Mr. K. R. Kiddoo, Professional Placement Manager, Sunnyvale, California. Lockheed is an equal opportunity employer.

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Technical Countdown

ELECTRONICS

25-MW Battery To Power Laser

A 25-Mw rechargeable nickel-cadmium battery is slated for use as a laser power supply later this year by the U.S. Army Missile Command at Redstone Arsenal, Huntsville, Ala. Under development by Gulton Industries, the battery will be capable of generating an extended series of 5,000-ampere pulses at 5,000v. To achieve these very high currents in short pulses, a bipolar form of construction is used. In conventional rechargeable cells, the nickel and cadmium plates are kept from internal contact by a separator, and current flows from cell to cell through inter-cell connectors. In the bipolar cell, a 0.003-in.-thick impervious metal sheet is clad on either side with nickel and cadmium plates. This whole backing sheet serves as the inter-cell connector, greatly reducing energy losses. "The 25-Mw battery will contain several thousand pounds of active electrode and be about the size of a telephone booth," explains Dr. Robert C. Shair, vice-president of Gulton's Battery Div. "For ease of handling, it will be broken into smaller modules of several hundred plates. One module will be about 3 ft. long, 1 ft. high and 6 in. wide," he added.

NASA To Get New High-Speed Computers

Six IBM System 360 computers in the Model 90 series are slated for installation in 1967. Up to 100 times faster than the IBM 7090, the Model 90 is being procured by NASA's Goddard Space Flight Center, The Goddard Institute for Space Studies in New York City, and Lockheed-California Co., among others. One-a-month deliveries of this large system are expected through 1968. Improved techniques for overlapping memory-access operations enable the computer to read at an effective rate of one character, or two decimal digits, in eight nanoseconds. High-speed circuits provide add times down to 120 nanoseconds for two 16-digit numbers.

Photomultiplier Efficiency Raised

Marked increase in quantum efficiency of a photomultiplier tube with a S-20 cathode has been achieved by ITT Industrial Laboratories, using a glass faceplate that produces multiple reflections onto the cathode surface. Intended for use with laser beams, the new technique was demonstrated on a special version of an F4003 tube, producing a gain in quantum efficiency of 3.5 times at 6,493 Angstroms and 2.5 times at 5,230 Angstroms. The faceplate and rectangular photocathode provide an instantaneous effective photocathode 0.75 in. long by 0.1 in. wide. The faceplate, which is in contact with the top surface of the cathode, has a prism at one end that inserts the incoming laser beam into the cathode at an angle of 52 degrees to the normal. Multiple reflections then take place between the surfaces of the glass plate. Additional experimental work involving specially processed doped trialkali photosurfaces and prismatic light injection has resulted in a yield enhancement factor 9 times that of a standard S-20 surface, at 8,000 Angstroms.

PROPULSION

Hydrazine Thrustor May Go On Backpack

TRW Systems is testing a 1-lb. thrustor about the size of a fat pencil for possible application to astronaut backpack maneuvering units. Hydrazine fuel is fed into a platinum composite catalyst (Spontaneous Shell 405) to produce thrust. Key to the development is a unique injection concept producing very square pulses. Peroxide has been the standard fuel for such thrustor concepts in the past, because hydrazine freezes at 35° F. However, by selecting a proper blend of hydrazine, it can be made to remain liquid down to — 60° F. Flame temperature of the engine is low—1,800° F. Thrustor is 4¼ in. long, with a maximum diameter of one inch and a minimum diameter of ½ in. at the engine portion, and weighs 0.4 lb. The engine operates with a chamber pressure of 175 psi and has an expansion area ratio of 40:1. In a backpack, as many as 16 units would be carried, plus a fuel tank.

MATERIALS

Electron Beam Used To Produce Sapphire

Single sapphire crystals of up to 3/16 in. diameter and 5 in. long have been produced by an electron beam process that yields high purity and crystal perfection. Developed at Materials Research Corp., the technique gives crystals with a dislocation range of 1,000 per sq. cm., compared with 1,000,000 per sq. cm. by flame fusion and Czochralski techniques. Substructure, voids or gas pockets are not visible and no mechanical working is required. The usual 60-degree orientation used for many laser and optical applications is now available in limited quantities. The process consists of float-zone melting of rods prepared by sintering of high-purity alumina powders. Melting is achieved by impinging high energy electrons on the rod. Crystallographic seeding techniques have been developed so that orientations of the basal plane from 10 to 75 degrees from the crystal axis may be obtained.

Solid-State Materials Analyzer Developed

A compact X-ray analyzer for identifying chemical elements within a material has been developed by Lawrence Radiation Laboratory, University of California. It exploits improvements in the energy resolution of semiconductor X-ray detectors. Developed by the Nuclear Chemistry Div., the instrument uses cobalt 57 or americium 241 to irradiate the test material. Characteristic X-rays excited are detected by germanium or silicon devices and displayed as an energy spectrum. From this, specific elements can be identified.

Roll Diffusion Bonding Studied for Titanium Tank

Manufacturing aspects of titanium roll-diffusion bonding are being investigated at Battelle Memorial Institute in support of North American Aviation, Inc.'s development of a 120-in. cylindrical rocket fuel tank. NAA's Los Angeles Div. is fabricating the tank under contract from the Rocket Propulsion Laboratory, Edwards AFB, Calif. Containing two compartments, the tank will be fabricated from roll-diffusion bonded titanium truss-core plates that are 0.4 in. thick overall. Core thickness will be 0.3 in. Each of the two face sheets will be 0.05 in. thick. Internal truss ribs will be 0.01 in. thick. In an 18-month research support program, Battelle will determine the time and temperature processing requirements for rolling the sandwich configuration and analyze the effects of the lay-up before rolling on the final configuration of the sandwich structure. Battelle will also study possible contamination problems and investigate interdiffusion of iron matrix inserts with the titanium structural material. Iron inserts are used as a matrix material to support the internal structure and provide its final truss configuration. They are leached out with a chemical reagent such as nitric acid.

PART I: SURVEY

Comsat Use Should Swell Dramatically

More than 25 countries are due to have ground stations by '71; major problems are in areas of international agreement, compatibility

by Rex Pay

COMMERCIAL COMMUNICATIONS via satellite promise to grow rapidly in the next five years, in spite of problems of international agreement and conflict with established interests.

By 1971, at least 25 countries expect to have ground stations, and many more might have stations if the U.S. were to reorient some of its foreign aid programs in this direction.

The outlook for military applications of communications satellites is equally bright. There is enthusiasm for their use throughout the services. All are agreed that there is a strong need for the special advantages they offer, and they are seen as a very significant step forward in improving nearly all kinds of military communications.

In the next 10 to 20 years, satellite communications promise to expand so rapidly that they will be handling far greater quantities of information than previously projected on the basis of current telephone use and population growth.

The wide bandwidths satellites offer will open up new applications in such areas as time-shared data processing, video data links, wholesaling of information transfer to television stations and newspapers, direct broadcast of radio and television to homes, and great expansion of educational and library-type television systems.

At present, communications satellite systems are taking the first baby steps of a new technology that has just crossed the threshold of practicality.

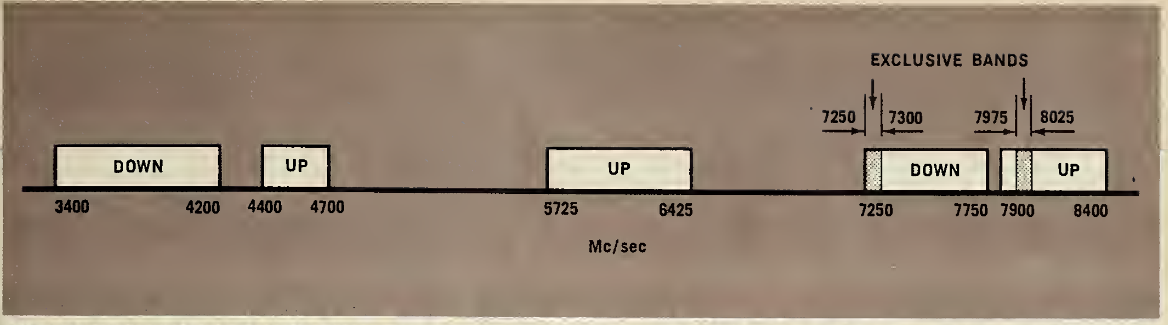
"The whole applications area of communications satellites is just burgeoning," Morris Feigen, manager of TRW Systems Group's global communications satellite development, told MISSILES AND ROCKETS. "An awareness of the possibilities is suddenly dawning on people. The technology is now making it economically feasible to provide new services, and imaginative people all over the world are beginning to see where they can adapt these."

Within the U.S., educational television distribution to local centers, such as that considered by California, may be the first new type of application to appear, because it conflicts with fewest established interests.

At the same time, growth in satellite telephone channel usage across the Atlantic will be continuous, with more of the developed countries equipping themselves with ground stations. Then coupling of the under-developed countries into this growing U.S.-Europe-Australasia telephone net will take place, at the same time opening the way for national and international communications growth within the under-

Philco estimates for channel costs over 2,000-mi. links. Economic advantage of satellites is even greater for longer distances.

SYSTEM	INITIAL INVESTMENT (MILLIONS OF DOLLARS)	ANNUAL OPERATING & DEPRECIATION COSTS (COST PER CHANNEL) THOUSANDS OF DOLLARS		
		600 CHANNELS	72 CHANNELS	12 CHANNELS
MICROWAVE RELAY*	16	10	74	440
SUBMARINE CABLE*	17	—	44	264
TROPOSPHERIC SCATTER*	30	—	112	676
COAXIAL CABLE (L-3)*	40	16	128	764
SATELLITES	4	10	20	78



All except exclusive bands of satellite frequencies are shared with other services—such as radar, surface microwave links and tropo-scatter links. This limits the amount of permissible satellite-radiated power and holds back development of small terminals.

developed areas of the world themselves.

Wideband communications through satellites will be slower to appear, but could be accelerated by educational television, information-service television, or data-processing requirements in the under-developed countries.

Communications explosion—RCA estimates that some $150 million has already been spent or allocated for the spacecraft segment of communications satellite systems—commercial, military, and experimental. The company estimates that $500 million will be spent on worldwide procurement of ground stations between 1966 and 1971, and qualifies this estimation as "pessimistic."

According to projections by the long-term planning group of Stanford Research Institute, the communications industry will overtake the transportation industry in dollar volume in the U.S. in 1977, to reach a volume of $50-60 billion per year. Communications satellites will be one of the strongest catalysts for growth within this industry as that period draws to a close.

Satellites themselves present the least of the problems to be overcome if their global potential is to be realized. Main stumbling blocks are in setting up international agreements for the use of this new medium and design of multiple-access systems to suit countries with widely different communications channel requirements.

At Rand Corp., John L. Hult, associate head of the electronics department, believes that many new users of communications satellites are to be expected as a result of developments in satellite technology. "Our work indicates that future communications satellites could support much greater use of this medium," Hult told M/R. "Some of the developments that will permit this are new techniques for reliable, long-lived attitude-control effective up to very large orbiting apertures; array lens antennas capable of supporting many simultaneous high-gain beams with the same orbiting aperture."

Techniques such as these will make it possible to broadcast from one stationary satellite directly to home receivers scattered over a very broad area.

Costs to come down—Evidence of the economic advantages of communications satellites within the U.S. is not hard to find. The American Broadcasting Co. has requested permission from the FCC for a communications satellite for relaying program material to its television stations throughout the U.S. because this would be cheaper than to lease land lines.

Hughes projects that a global communications satellite will have a channel cost per year of $600, compared with *Early Bird's* $16,000.

Studies at General Electric's Tempo organization show that the bit-rate charge of systems-optimized satellites that use current technology would be one-tenth of the rate for *Early Bird*, and *Early Bird* is competitive with land lines.

"The hard technical pioneering work has already been proven. We have a viable technology in being," concludes Gibson M. Wolfe, communications system analyst at Tempo. "But in the U.S. two problems remain. First is compatibility with existing ground systems—such as television, UHF, microwave links, and HF. Second is the fact that communications satellites will interfere rather violently with established systems in the economic sense over the next 10-20 years."

The long-line companies in the U.S. have just completed modernization of their facilities, including remote routing and hardening. It will take 10-20 years to amortize this new investment, even with a schedule F tax writeoff.

"If the long-haul communications industry is as lethargic and as investment-capital dominated as, say, the auto industry, then it may be 20 years before communications satellites come into commercial use within the United States," commented Wolfe.

An important indicator to watch in this respect is next year's capital appropriation in AT&T's Long Line Division. If this is big, the outlook for satellites is bad. The present year appears to be a "wait and see" period for division.

Satellites bring problems—There are also difficult international agreements to negotiate if communications satellites are to come into wide use. Most of the new satellite systems being proposed or studied are illegal.

International agreements allocate frequencies to communications satellites that are shared with ground services, and because of this the allowable signal power levels from satellites have been limited to prevent possible interference.

Except when spread spectrum or pulse techniques are used, "this limitation will handicap systems attempting multiple-access operations with small Earth stations. Also it does not encourage the development of advanced satellite systems incorporating highly directional antennas," comments a Rand report prepared for NASA.

There is a variety of conflicting interests that have to be reconciled if international agreement on favorable spectrum-use allocations are to be obtained for communications satellites. The main question is how various forms of broadcast satellites will be used.

Applications of communications satellites fall into two main categories—those for technologically advanced areas and those for underdeveloped areas. The communications requirements for the two differ, but a particular satellite may serve both. The NASCOM/Interim satellite to be located at 6 degrees west meets an advanced technological requirement of the U.S. by improving communications with orbiting spacecraft. But it also has channel capacity that could link countries in Africa or South America, or link them to the U.S.

Also, the use to which communications satellites are put in one area will affect their application in other areas. State-wide educational television in the U.S. relayed by satellite would give a boost for this form of education in other countries. Development costs would have been met in the U.S.

Similarly, if Chile, Brazil, and Argentina were to implement a common time-shared computer system through a communications satellite (computer and satellite economics suggest this possibility), this would have to be preceded by an international agreement that would also open the way for data transmission to and within the U.S. by satellite. Such an agreement would be much more difficult to negotiate if it was requested by the U.S. as a requirement of the Central Intelligence Agency.

With this background, the 1968 International Telecommunications Union Conference promises to bring heated discussion. "The difficulty is that the conference will be talking of truly global communications systems that are now feasible," said John M. Sullivan of Tempo's defense programs operation. "It is really a different kind of system than what we have had until now."

"The fabric of international communications is one in which there is a great deal of tolerance," added Sullivan. "Nobody would want to upset the rapport that has been established. Yet you have to go through the ITU to be able to implement some of the things that have been demonstrated as feasible."

Satellite propaganda—The conference in 1968 will move into much more speculative areas than those dealt with by previous conferences, particularly in considering the allocation of frequencies to broadcast satellites. NASA has already requested studies on a broadcast satellite that can relay programs direct to short-wave or FM home receivers. The Voice of America is interested in this, but Russian and European opposition might appear.

Quite possibly, said Sullivan, questions such as these will not be discussed at the ITU conference. Instead, some rules might be drawn up for just a small part of the capability of satellites, but the real problems will be side-tracked.

Fred H. Gedicks of TRW Systems suggests that the question of higher ground densities for the satellite signal will have to be forced as an issue by studies of large satellites such as those of NASA and Comsat Corp. The time between deciding to go ahead with satellites such as these and bringing them into service is about three years, said Gedicks, which provides time to resolve the problem internationally.

Some of the internal political problems that direct-broadcast satellites pose have been outlined by Richard Pinkham, senior vice president in charge of media and programs for Ted Bates and Co. and chairman of the broadcast policy committee of the American Assn. of Advertising Agencies. In effect, a broadcast satellite would enable the big television networks to bypass local stations. This would not take place without a fight, said Pinkham, because broadcasters have "quite a lobby in Washington," and also it is FCC policy that television should first serve local interests.

However, he doubted whether any policy or lobby could hold out long against such a technical development, and foresaw the emergence of as many as 10 national networks. This could not only be alarming for local television stations but also for Canada and Mexico, if the network's coverage should extend to them.

New economic concepts—More will be involved in ITU and FCC deliberations than frequency and power-density agreements. The ABC proposal involves an economic concept that these agencies have not been concerned with before—the use of the radio spectrum for the wholesaling of information to a privileged group of receivers. A similar situation arises in the applications for satellites by data-processing organizations and members of the stock exchanges.

One point often missed is the significance of satellites in medium-distance communications. Satellites are clearly recognized as preeminent over long distances. But they can be economically viable over distances of 500 miles. A point-to-point land line for this distance will cost $2-4 million, and it is fairly inflexible. At this price a satellite becomes competitive because of the greater flexibility it offers.

This has led the state of California to consider whether a satellite might be used instead of land lines to distribute state-wide educational television to some 5,500 day schools in the 1970's. Results of this study are expected at the end of January, but the chief satellite system considered is understood to have involved 25-50 ground stations, feeding schools in their local area by land line.

Military Satellites Exploit Bandwidth to Defeat Jamming

ALTHOUGH COMMERCIAL and military communications satellites perform similar functions, their designs emphasize different requirements. Commercial systems have to be economic; military systems have to be invulnerable to physical attack or jamming.

To meet the threat of physical attack, military systems seek safety in numbers. It is not practical to use thermonuclear weapons against each of a large number of satellites. Furthermore, the radiation density that remains is limited. Electronic circuits have to be hardened, but even the fireball of a nuclear explosion does not black out X-band communications.

The most familiar proposals for preventing or degrading jamming interference in military communications satellites are spread-spectrum and frequency-hopping techniques. Spectrum spreading can be achieved by converting the message into a digital signal and then modulating this with a pseudo-random digital sequence of high bit rate. Only the communicators have access to the specific modulating bit sequence. By using correlation techniques, reception is possible even at negative signal-to-noise ratios.

Circumvention—Using a hard limiter, a pseudo noise system with 40-mc spread bandwidth can provide a full-duplex voice channel through a spinning satellite at an 18-db jamming-to-signal ratio, according to calculations by Wilbur Pritchard and Neil MacGregor of Aerospace Corp.

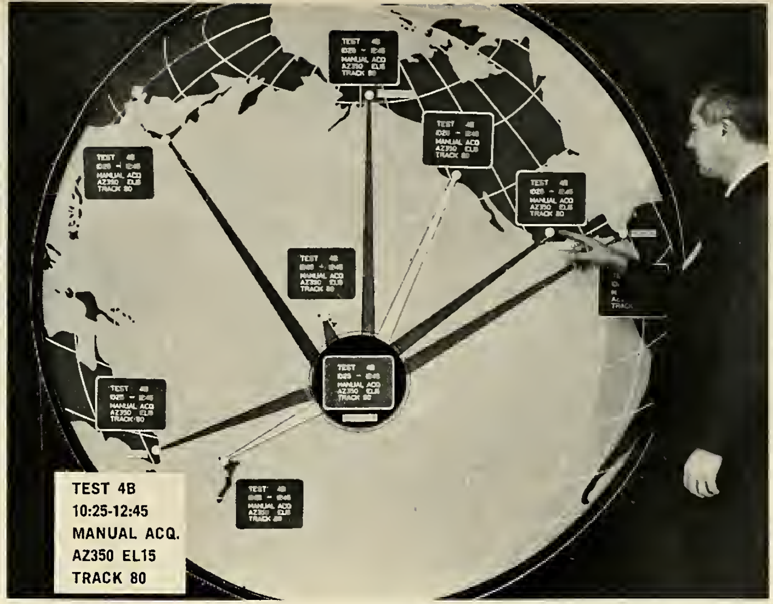
Code division multiplex modulation can be increased in jam resistance, without increasing acquisition time, by switching a transmitter among a very large number of frequency channels.

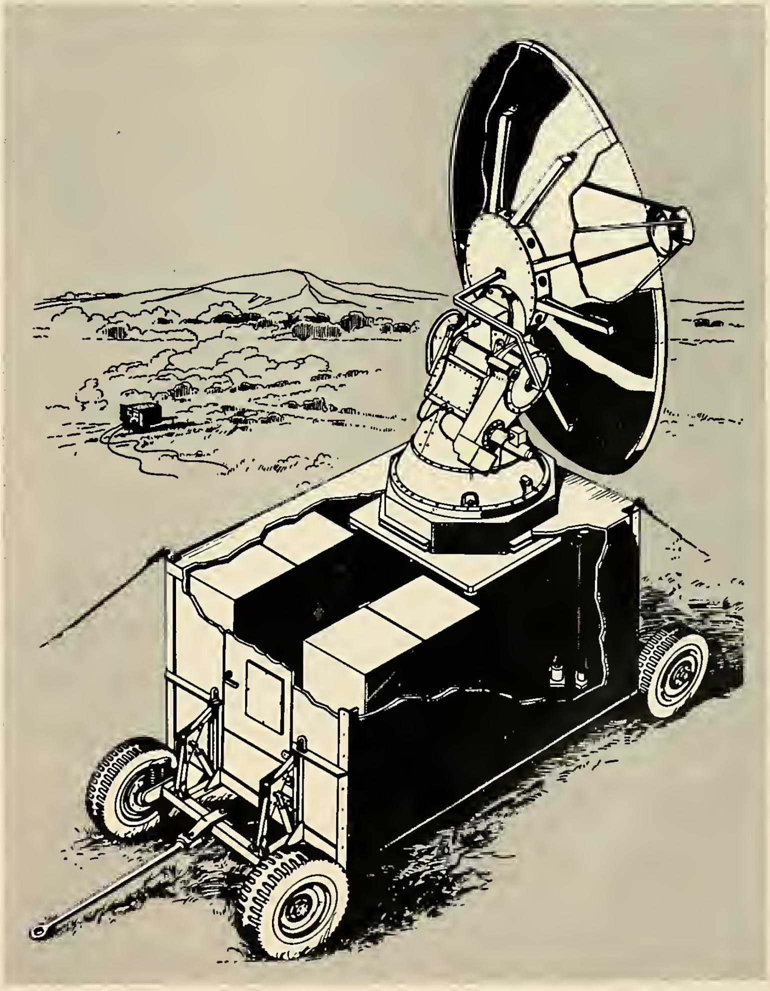
One advanced concept that may have applications in a jamming situation is the retro-directive array. R. T. Adams of Sichak Associates has suggested using a modified Van Atta array that is frequency steered. Operating frequency is then varied with range, so that all signals received at a ground station at a certain frequency must come from a specific ground range. Then a jammer's frequency has to match his range.

YIG application—Another anti-jamming technique under study is the use of YIG devices that have frequency limiting properties. Watkins-Johnson Co. has made lithium ferrite devices of this type. Such a device will accept carriers of different frequencies and levels and cut them to the same level.

If a high-power jammer is not on the communications frequency, it will not be able to saturate the satellite system because it will emerge from the ferrite limiter at the same level as the other traffic. ■

Right: In Tasker display system status of satellite links is indicated by lines of colored lights. Cathode ray tubes display station activity. Lower right: A large potential market for mobile military ground stations is attracting many electronics firms. Sylvania Electric is developing a 4,000-lb., 12-ft. dish unit.





The same technology outside the U.S. could provide a country the size of Kenya with an internal communications system. In applications such as these, highly directional beams would be used, with perhaps several serving different areas from one satellite.

Data transmission growth—The impact of newly appearing time-shared computer systems on projections for future requirements for communications links could be dramatic, said Wolfe, and may only be met by use of satellites. Since Tempo at Santa Barbara, Calif., has been linked to central computer systems at Phoenix, Ariz., and at Dartmouth College, Hanover, N.H., the organization has quintupled the amount of data it is processing. Costs of computation have been nominal compared to the advantage gained by access to these very large computer systems.

"If our experience is reproduced by other businesses, the data transmission growth over the next five years will outspace the capacity of all the long-line systems," said Wolfe.

If developments such as this lead to communications nets with wide bandwidths at low cost, said Wolfe, the way would be open for the introduction of phone links equipped with television, using perhaps 50-kc bandwidth per channel. It can cost up to $500 to send an executive from the West to East Coast of the U.S. to attend a conference that might last only one hour, said Wolfe. An equitable charge for a vision phone service might therefore be $250—to give a 50% saving and a considerable rise in individual productivity by removing the need to travel.

Once such a system became available, the demand would probably rise very rapidly. There are other systems already being installed that could make use of such a communications net. For example, NASA's Marshall Space Flight Center is acquiring a magnetic tape and television system for retrieving documents. This is being installed by Ampex and could be modified for remote access from widely separated points in the U.S.

There are many applications of this type, in which information from a document or person could be brought directly to an inquirer, that have promise of an economical solution in communications satellites.

Markets in under-developed areas—Under-developed countries could bene-

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fit from communications satellites in two ways—they can provide links within regions with poor communications, and they can link countries in such regions to the extensive communications networks that link technologically advanced countries.

Todd G. Williams, manager of Philco Western Development Labs advanced systems department, believes that the second type of communications link will grow first, because underdeveloped countries will want to be linked to rich sources of information. However, analysts at Tempo point out that advanced technology has turned out to be of little value to under-developed countries. They have more need for the technology of 50 years ago. They might therefore be more interested in sharing their experience among themselves and establishing central clearing houses for common problems, operating with the aid of communications satellites.

From the political point of view, countries in Africa, South America, and Asia are likely to welcome the opportunity that satellites will offer for direct communications with the United Nations and with political centers throughout the world.

However, from the near-term economic point of view, the conspicuous poverty of many of the under-developed countries does not offer much promise of profit to a communications satellite agency. Indeed, investment in systems for such areas may take the form of risk capital to prime the pump, hopefully to lead to growth of demand.

Furthermore, while it is possible to view areas such as Africa from the U.S. and say how useful a communications satellite system would be for African unity—for facing educational problems, for disseminating agricultural, medical, and health information—it does not follow that these opportunities will be seized by the people they are intended for.

In this respect, the experience gained with the recently installed television system in South Vietnam will be of interest, both in the Vietnamese response to it and in the way the system withstands the conditions in that country.

Satellites as foreign aid—President Johnson's Citizen's Committee on Communications, headed by Harold S. Geneen, president and chairman of IT&T, believes that improved communications have a vital role to play in under-developed countries. The committee predicts that the ITU will be able to accommodate the new developments in technology and urges that these services should be used to disseminate medical, agricultural, meterological, technical and educational information "which is indispensable to social progress in all areas, especially in the less developed areas of the world."

The committee proposes that a central agency, "The Voice of Peace," should be set up for this purpose by the United Nations, with U.S. support.

An essential part of this proposal is an awareness by the committee that a worldwide communications service must be provided at a price even an under-privileged nation can afford—that aid must be given in providing facilities such as communications channels, radio and television equipment.

Dissemination of agricultural information as a form of aid to underdeveloped countries is now carried out in a number of ways, including agricultural agents, Peace Corps, and college exchanges. Quite possibly it would be much cheaper to put this information where it is needed if satellite communications were used.

"Fifty percent of the people trained in the U.S. do not go back to their native country," said Sullivan; "80% of those who go back become big wheels located away from areas where their personal help is needed, and the rest, who are at the points where they can be most effective, have difficulty in getting their message across."

In this situation, said Sullivan, it might be better to bring the information and education directly to the point where it is applied. "Television can put a teacher in a classroom in a remote area that could never persuade any teacher to go there personally," said Sullivan. "One of the stronger applications for satellites in Africa is for education."

As the Citizens Committee pointed out, to implement this idea would call for the provision of radio and television equipment as a form of aid. What is often not realized, said Sullivan, is that present methods of disseminating information involve quite high levels of aid. "There is a minimum cost of $25,000, which may easily become $40,000, for a skilled expert to go abroad. When you take into consideration the number required in each country, you soon get up to the kind of cost for terminals for an optimized comsat system".

State department seminar—The Citizens Committee notes that planning is needed to avoid purchase of equipment that is inferior, inadequate or incompatible with systems already in use in a country. It recommends that the U.S. should increase its participation in the technical assistance corps of the ITU, criticizing the fact that there is no U.S. engineer in that corps.

These recommendations have not fallen on deaf ears. A move to greatly increase the spread of U.S. technology in the construction of ground stations for satellite communications is now

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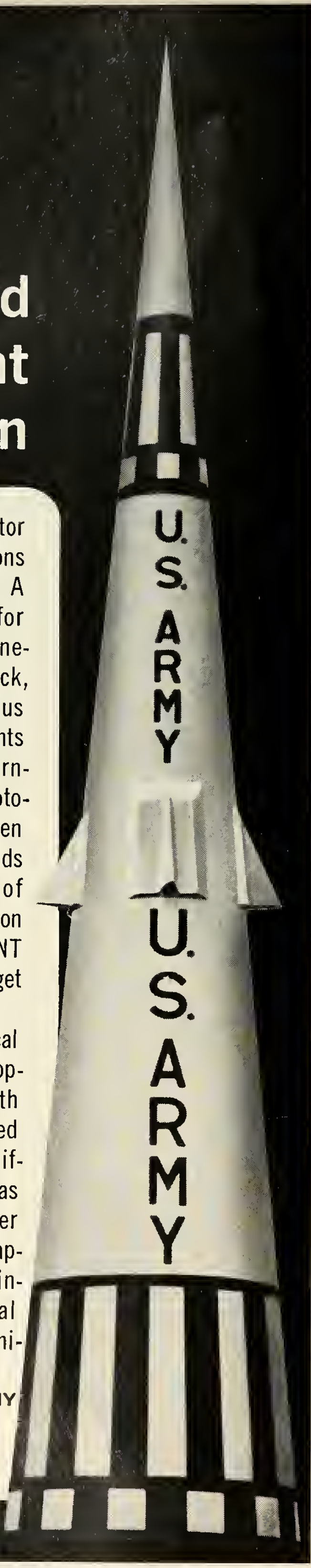

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under way in the Dept. of State.

The plans involves a "Seminar on Satellite Communications," to be held in Washington, D.C., May 16-27 for member nations of the ITU. The meeting was given official State Dept. approval earlier this month. Richard T. Black of the office of telecommunications is in charge of general arrangements and coordination.

Purpose of the seminar is to bring the state of the art in ground-station development and design to the lesser-developed nations hoping to participate in the global communications satellite system of the International Telecommunications Satellite Consortium (INTELSAT). The program will include presentation of technical information, limited hardware exhibits and field trips to Earth stations and manufacturing facilities throughout the U.S.

Although the ITU has long encouraged technical seminars for underdeveloped nations, this is the first time such a project has been held in the U.S. Recent meetings on ground-station technology have been conducted in Britain and Japan. Program officials here are expecting representatives from 25 to 30 nations that desire Earth stations but have made little or no progress toward construction of one. Because of the limited size of State Dept. facilities, total attendance will probably be kept at about 75 persons. The ITU is now working on preliminary arrangements for invitations.

Other participants — Cooperating with the State Dept. are the Comsat Corp., NASA, the Dept. of Commerce, the FCC and other government agencies. All-out industry support—an early estimate is 15 to 20 U.S. companies—is expected for the seminar. Also involved will be U.S. common carriers, particularly AT&T and ITT.

While the seminar is not a commercial presentation, U.S. firms have been enthusiastic in their support, program officials say. Although all details are still tentative, it is expected that Hughes Aircraft Co. will have its experimental ground station in Arkansas in operation by May and will probably offer tours of that facility.

Page Communications Engineers is expected to have a transportable ground station in operation in the Washington area at that time. It is also possible that ITT and Sylvania Electric Products, Inc., will have transportable ground stations in operation. Radio Corporation of America is also expected to participate intensively in the program. Comsat is considering tours of its control center in Washington, D.C., and its leased ground station at Andover, Me.

Papers will be presented on satellite communications principles (including tariffs and rates), ground site selection, Earth station equipment, existing and planned ground stations, and economic considerations.

Ground terminals—Costs of ground terminals now tend to limit usefulness of satellites such as *Early Bird.* If costs could be reduced by use of pencil beams and better pointing accuracy, widespread use of such satellites by underdeveloped countries is likely.

Wolfe pointed out that present satellite systems were optimized for satellite reliability, and that component technology of five to six years ago was being used. "But if we set out today to optimize the *system,*" said Wolfe, "it would make a significant difference in system configuration, would reduce total system cost, and would probably be more reliable." Studies show this procedure would cut the bit-rate cost to one tenth of present systems.

Studies of the reliability gains have not been completed at Tempo, said Wolfe, but initial indications were that reliability would be increased by at least a factor of two and maybe by as much as a factor of 160. The aim would be to produce a ground station as simple as common HF multiple-diversity ground stations and with comparable costs ($50,000 per channel), said Wolfe.

Countries throughout the world are contacting U.S. manufacturers with detailed inquiries for ground stations. "We have had inquiries from everybody—alphabetically, from Algeria to Zambia," Dr. Nichols Yaru, manager of Hughes Communications and Radar Division, told M/R. Yaru points out that many of the under-developed countries can afford Boeing 707 aircraft as a matter of national prestige. It is likely, therefore, he suggests, that they can also afford a satellite ground terminal.

According to Dr. Paul Visher of Hughes, a simple antenna for a synchronous satellite would cost $500,000 with the complete terminal costing $2½ million.

The question of ground terminal design is currently receiving considerable scrutiny in the U.S. Rand reports that there is a potential market of at least 141 countries, and possibly a requirement for another 100 stations to serve isolated communities.

The sensitivity of the ground terminal that Comsat Corp. will permit to communicate with its satellite will probably be standardized by the agency. Less sensitive Earth stations reduce the ground equipment cost but force up the satellite cost per channel. As antenna sensitivity increases, satellite costs come down and ground equipment costs go up. Optimum Earth station sensitivity is determined at the minimum total per channel system cost.

Optimizing antennas—In the economics of Earth terminals, the ratio of the ground-antenna gain to the receiver system noise temperature determines the number of channels provided by a given satellite. This corresponds to the revenue returned by the satellite. Philco's Williams has shown that the most economical station for a large capacity user is one with a minimum gain-temperature ratio of 40.7 db. For the small-capacity user, the figure can be reduced to 37 db, but if growth of demand causes channel requirements to rise above 12, a 40-db terminal will be needed.

In terms of hardware, this implies a ground antenna of 85-90 ft. and a preamplifier with a noise temperature of about 14 degrees K. And currently this is the type of equipment on which manufacturers are concentrating their commercial development programs. Both Philco and Hughes are developing antennas of this size and equipping them with appropriately cooled parametric amplifiers.

Working on its own projections of the number of channels that will be required for its links, Comsat has found that a dish of about 85 ft. and a receiver system noise temperature of 50 degrees K is optimum for the next 5-7 years for telephone point-to-point communications. This means using a maser, or maybe in the future a parametric amplifier.

Comsat hopes that other nations will build ground terminals to meet this standard. "However," said Dr. S. W. Spaulding, "we do not mean to take the position that someone with a different antenna could not use our equipment. In effect, we are the worst offenders in this respect because we have to work with much smaller antennas on the NASA ships."

Comsat provides enough power density from its satellite at a ground station to bring in telephone channels meeting international standards, if the user has a receiving system like Comsat's. If a user wants to have a lower-sensitivity terminal, his application and the charge he has to meet will be decided on an individual basis.

It turns out that there are not so many countries requiring only very few channels as was supposed. Although many countries need only a few telephone channels, most of them want to be able to receive television, which dictates a sensitive station.

The main point of argument is in the sophistication of the mount required for such antennas. Philco has not firmed up its design yet, but is currently working on an azimuth-over-elevation mount with a high-accuracy tracking capability, suitable for any type of satellite system. Hughes Ground Systems Division is

collage

More Motorola mishmash, continued from page 6

To Hell With Pavlov

As any fool knows, the triggering mechanism of the Venus Fly Trap plant is activated only when one or more of its six hair-like antenna things are titillated at least twice. So this week's class project is to keep sneaking up on one of the carnivorous beasties and agitate an antenna just *once* each time. Before long it'll become psychotic . . . snapping at passing Yamahas or just saying to hell with it and going vegetarian.

Sic Transit Gloria Murphy

Our Western Center's Earl (not Gloria) Murphy is driving a few *people* mad by cross-breeding both hardware and language. He mated an antenna with an amplifier to produce an "antennafier"; an "antennamitter" resulted from some hanky-panky between an antenna and a transmitter.

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Continued on page 79

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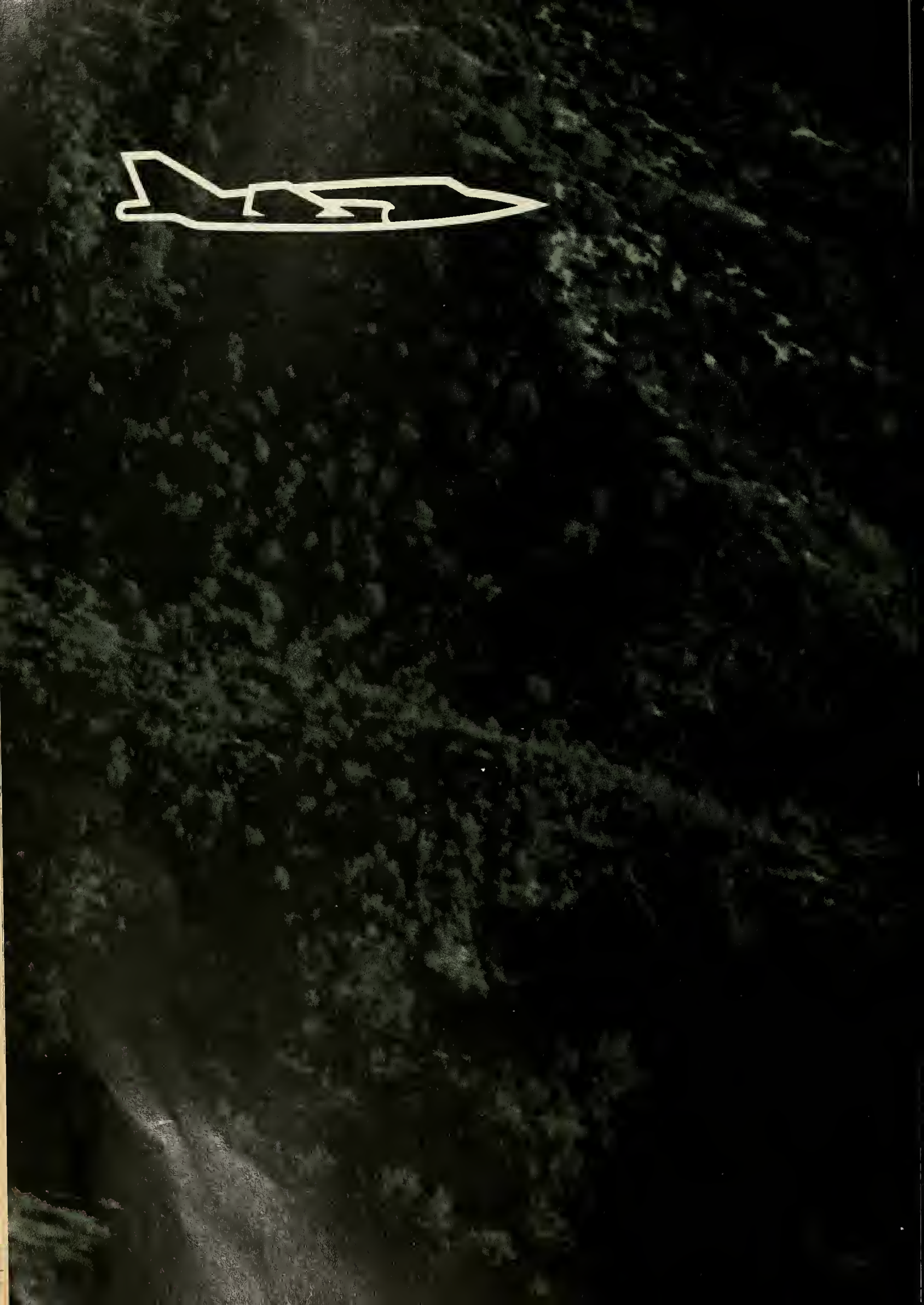

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If yours is the need to know, contact Art Sommer at One Space Park, Redondo Beach, California 90278.

TRW SYSTEMS

attempting to develop a low-cost mount at its Arkansas site for operation with synchronous satellites only. This would carry an 85-ft. dish and may be an equatorial mount. The aim is to provide full equatorial coverage but only limited vertical motion.

Electronic Specialty Co. is developing high-accuracy sidereal mounts on its own funds for synchronous satellite ground antennas. ESCO sees the sidereal radio telescope mount as superior to the az-el pedestal, because in this application only about ± 5 degrees adjustment in the declination axis will be needed. Provision of 180-degree adjustment in the polar axis makes the mount suitable for use around the world. No tracking would be required and the conical support tower will be much shorter than a general-purpose az-el mount.

Henry Blanchard of Stanford Research Institute points out that present systems favor exposed antennas with very low sidelobes and use multiple reflector techniques to avoid having to rotate the transmitters and receivers with the antenna. However, he believes that for low-traffic terminal equipment, considerably simpler Cassegrain antennas can be used, particularly in lesser developed countries, in which radar, microwave link, and other interference is not significant.

Philco WDL believes that a high-performance antenna will be needed at ground stations and has developed a 90-ft. quasi-parabolic reflector with specially shaped sub-reflector. The special shaping of the surface results in uniform illumination of the antenna's aperture, which provides an efficiency of 98%, compared to the 75-80% of classical Cassegrain reflectors. An extra 1-db of gain is achieved in this way. Tracking accuracy of the antenna system is 0.03 degree in both axes.

Philco recommends that a ground station should have two antennas of this kind, both steerable, to have operational compatibility with all satellite systems. The dual configuration is required to reduce circuit outages to a level consistent with commercial service, according to Philco estimates.

Military antennas—Where portability is required, notably in military ground stations, use of lightweight materials such as aluminum honeycomb and exploration of new forms of antenna array are taking place.

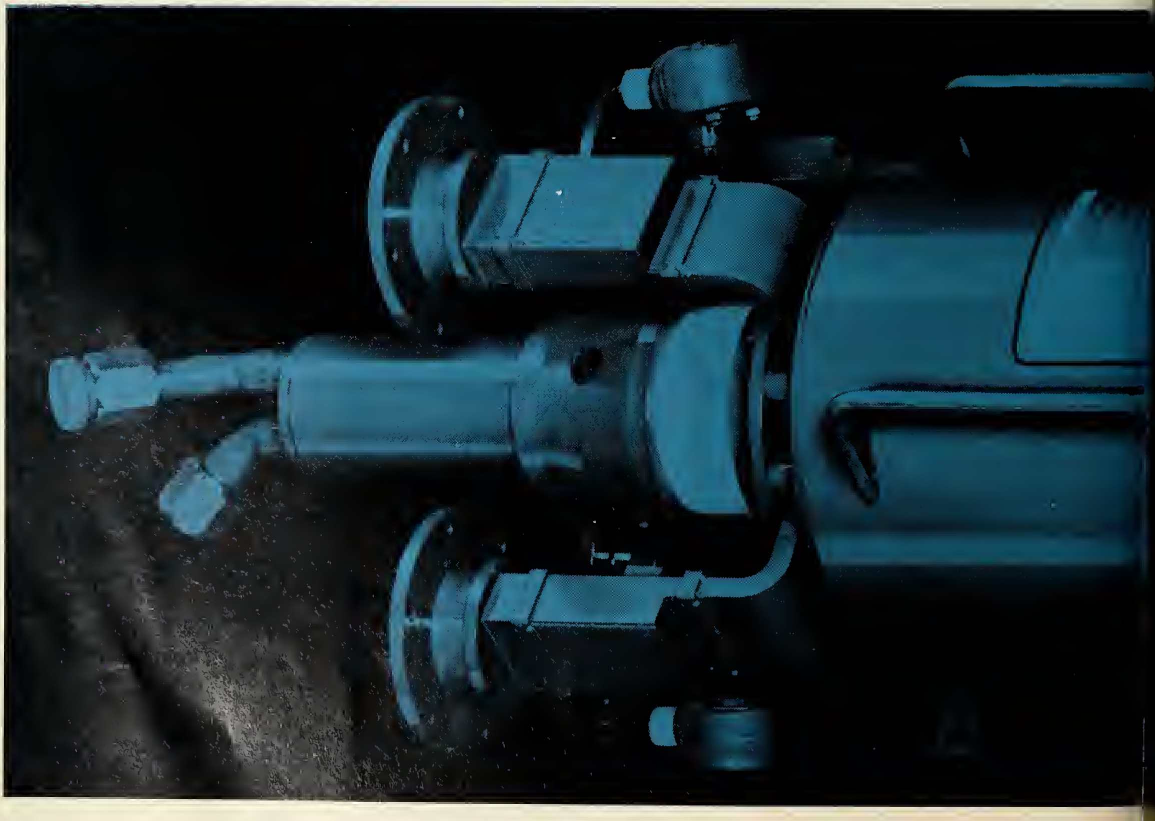
Splitting up a large parabaloid antenna into a set of smaller parabolas produces a marked decrease in weight —up to 4:1 on very large antennas, says George Shaw, vice president of Radiation, Inc. This design is being used on the AN/TSC-54 antenna Radiation is delivering to the Army.

A similar construction is used on the *Apollo* communications antenna that Dalmo-Victor is constructing under contract to North American. The Command and Service Module antenna for communications with the unified S-band system is an array of four parabolas, each about 24 in. in diameter. Honeycomb structures of the dishes are being supplied by Solar Div. of International Harvester Corp. Different beam widths and sensitivities are obtained by using different numbers of dishes.

Honeycomb antenna dishes produced by the Advanced Structures Division of Whittaker Corp. have been supplied to Radiation, Inc., for the AN/TSC-54 (four 10-ft. reflectors) which operates at X-band. However, the surface finish obtainable with honeycomb structures is currently 0.009 in. rms, which will meet most specs for K-band antennas and operate usefully up to Q-band. A similar tolerance is achieved in 12-ft. and 16-ft. honeycomb reflectors made by the firm.

Of the larger non-mobile antennas, the Raisting station in Germany and the Japanese ground station make use of honeycomb structures.

Power tube advances—In ground station technology, power tube design is advancing to meet the needs of commercial and military systems. For the NASA *Applications Technology Satellite* program, Varian has developed the



VA-884, one of a family of broadband tunable klystrons. As part of its package design, this tube has a complete remote tuning system that allows the klystron to be tuned across 5.9 to 6.4 gc in minutes. This unit is being used in Comsat Corp. transmitters.

For tactical terminals, Varian has developed the VA-925 8-kw klystron, tunable from 7.9 to 8.4 gc, water-cooled and weighing 100 lbs. The VA-881 is air-cooled, produces 6.5 kw, and weighs 70 lbs. Both tubes have 40% efficiency.

As far as future solid-state devices are concerned, research workers at Varian speculate that Gunn-effect oscillators will achieve 10 kw at 1 gc and perhaps 100 watts at 10 gc. So far, 105 watts at 800 mc and, with two devices in parallel, 205 watts at 1,540 mc have been achieved at Varian.

Multiple access problem—Multiple access to a communications satellite continues to be a problem pursued by many organizations. How a system degrades as stations using frequency-division-multiplex with frequency modulation increase has been computed by Wilbur L. Pritchard and Neil MacGregor of Aerospace Corp. They show that if one carrier has a capacity for 700 channels, the same system when using 16 carriers has only enough capacity for 10 channels per carrier, a degradation of 77%.

"There is no clear-cut solution for the multiple access problem," said TRW's Feigen. "The situation is easy if all ground stations have the same channel capacity, but channel requirements are likely to vary from nation to nation."

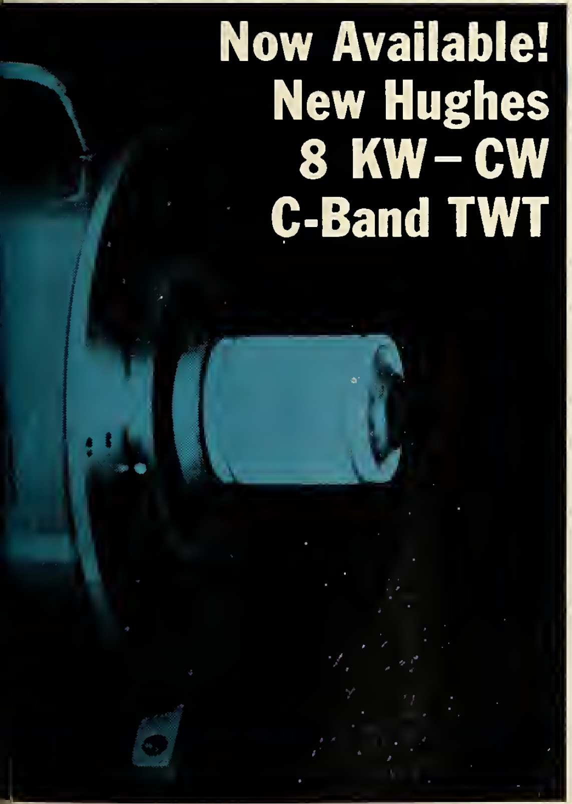
On the other hand, Hughes feels it has the multiple-access problem licked with its satellite telecommunications with automatic routing (STAR) system. A capability of providing multiple access for 200 ground stations by increasing satellite bandwidth has been claimed by Hughes.

The STAR system makes use of a single voice channel per carrier and can redistribute its capacity minute by minute to match the needs of users. It calls for complex ground equipment at one central terminal, but simple equipment at all others.

Satellite developments—Two alternatives shape up for greatly improved effective radiated powers from communications satellites. One makes use of gravity-gradient stabilization and narrow-beam antennas. The other uses spin stabilization and a mechanically or electronically de-spun antenna. A de-spun antenna provides about 10-11 db of increased gain. A gravity-gradient stabilized satellite holds out the possibility of an antenna gain of 15 db, providing the satellite is not oscillating. These are minimum gains, toward the horizon.

Electronic de-spinning is the most promising development for the near future, and is scheduled for use on the NASCOM satellite and the global Comsat Corp. satellite. Gravity-gradient stabilization has yet to be demonstrated at near-synchronous altitudes, but will be tried out in the Initial Defense Satellite Communications Program this year, and later in *Applications Technology Satellites D* and *E*. In the *ATS*, a NASA/Ames concept that uses inertial coupling to reduce the number of damping elements will be tested. The de-stabilizing effects of station-keeping thrustors and torques from micrometeorites and solar radiation are main problems at synchronous altitude, where gravity gradient effects are extremely weak.

Display systems—In a synchronous-communications-satellite display system developed by Tasker Instruments Corp., a line of colored lights indicates the status of a communications link on a semipermanent overlay map. As each station provides a large amount of information that varies with time, cathode ray tubes coupled to a computer are inserted in the map at positions corresponding to the ground stations. Tasker's Model 401 character generator provides alphanumeric symbols in eight different sizes between 0.1 and 0.75 in. high, at up to 500,000 characters per sec. ■



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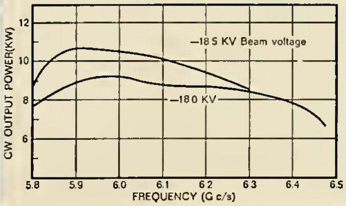
SPECIFICATIONS

5925—6425 Mcs	30% efficiency (depressed collector)
18 Kv beam voltage	40 db gain (saturated)
Tube weight: 30 lbs.	3.0 amps maximum beam current
Size: 28″ length 7″ diameter	Solenoid weight: 65 lbs.
	Cooling: water, 11 gpm



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PART II: COMMERCIAL SYSTEMS

Enthusiasm Grows for Global Comsats

Comsat Corp. global system should have 8-10 satellites in orbit by 1970; NASCOM interim program due to be operational by Sept. 30

by Charles D. LaFond

BY LATE SUMMER of 1968, every country with a suitable ground terminal will be within reach of the Comsat Corp. global satellite network. Quite probably the satellites will be in synchronous orbit.

Most experts feel that there will always be a need for synchronous-orbit communications satellites. The related transmission delay is no real problem and echo suppression equipment is now claimed to be adequate.

For high density trunk telephone traffic, a medium-altitude system with about 12 satellites may eventually be needed. But at present, the synchronous satellite has the upper hand because of the ease with which it permits phasing in of new technology. Put up one satellite and a system is underway; put up a new and better vehicle when it becomes available and the previous spacecraft can be moved to an operationally less demanding orbital position.

At the present time, this appears to be the plan of action for Comsat—over the next 5-10 years at least. The corporation looks on the whole as a continual system progression which started with *Early Bird* in 1965, will expand to 8 to 10 satellites in orbit by 1970, and will probably become forever indispensable by 1980.

Ground station spread—By 1975, at least 49 countries are expected to have Earth stations in operation—by their own estimates made in 1965. In the 1968-70 period, at least 20 stations will be in various stages of construction including those in Spain, Mexico, Australia, India, and Brazil (probably available for operation in 1967-69), followed by facilities in Ethiopia, Colombia, Switzerland, and Argentina. Additional U.S. stations also are expected during this period.

Typical cost for each of these stations (based on current U.S. dollars) will be in the $4-5.5 million range. The variance in price will depend on the prestige value assessed by each nation.

By the end of 1967, new Earth stations are scheduled to be operating in Canada, Spain, India, Japan and Brazil. The Canadian station at Mill Village, Nova Scotia, is actually expected to become operational "any time" for initial use with the *Early Bird* satellite. Spain's new facility, being constructed outside Madrid, will complement its present station at Grinon, which is being modified for increased capability with the global communications system.

Italy is also modifying its present ground station at Fucino for this purpose and is going ahead with construction of a second one. Technical design approval of the Indian station was recently granted by the international committee establishing the global system. The station is expected to be in operation by the first of next year. In Brazil, engineers from Comsat have been called in to aid in site selection for a station, scheduled for completion sometime in 1967. Japan, with state-of-the-art technology in ground station development, is moving ahead with construction of a station for the global network.

All stations under construction, Comsat officials said, are single 85-ft.-dia. antenna systems with high capacity and efficiency. They will be comparable to the stations being constructed by

TELESPAZIO

Left: Italy's first ground terminal at Fucino makes use of 44-ft. antenna dish, but a new 97-ft. dish will bring terminal sensitivity up to what is becoming a standard level. Right: Cutaway model of TRW Systems' global communications satellite shows main propulsion tank above wobble damper. At top of vehicle is electronically de-spun antenna. At least 1,200 two-way voice channels will be provided. Center right: Permanent Comsat Corp. antennas to be installed at Brewster Flat and Paumalu will have 85-ft. dishes on azimuth-elevation mounts with precise tracking capabilities. Extreme right: Initial communications from Brewster Flat and Paumalu will be carried by transportable folded horn antennas. One of these 42-ft. antennas will also be located at Andover. All will provide links to the NASCOM/Interim Global Satellite.

Comsat at Brewster Flat, Wash., and Oahu, Hawaii.

Many smaller nations are also moving ahead with plans for ground stations. Comsat has loaned engineers to aid in site selection to Kuwait, Israel, Colombia and Ethiopia. Also expressing serious intentions—with actual construction expected sometime in the 1968-70 time period, are Nigeria, Chile, Argentina, and Venezuela, the newest and 48th member of the international consortium. Switzerland has also expressed definite intentions to construct a station, Comsat officials said, but is in no real rush to do so. Estimate is that construction would come some time after 1970.

A station in Australia has long been assumed, but presently it hasn't been decided whether to build it on the east coast or west coast. Peru, not yet a member of the consortium but expected to join soon, has also indicated serious interest in a ground station. Thailand is another possibility for post-1970.

Comsat has been providing many of the under-developed nations free advice on a preliminary basis, particularly in the area of site selection. Other nations have received technical assistance on a longer-term basis through the International Telecommunications Union.

With the exception of Peru, Mexico is now the only nation not a member of the consortium that has a potential communications percentage of any substance. Mexico's potential quota—derived from a formula based primarily on international communications traffic —is approximately 1.7%. This figure would rate Mexico a seat on the international committee, now comprised of 15 members representing one or more nations with a total share of the space segment of at least 1.5%.

Although Mexico has made no formal moves toward participation in the global system, Comsat officials point out that the 1968 Olympics to be held there will almost force Mexico to build a station. The facility would pay for itself almost immediately, a corporation official said. Presently, Mexican communications are virtually a part of the U.S. network.

In the United Arab Republic 12 of the 13 nations have joined together and are represented by Algeria on the committee. There is a possibility that one or two stations will be constructed to serve these countries, Comsat said.

Early Bird—Comsat's first satellite, the 85-lb. *Early Bird,* went into commercial operation last June. Of its 240 two-way channel (circuit) capability, 75 channels were leased in 1965 and a steady growth rate is expected through 1966. Current limited use reflects the effort by potential clients to make full use of existing cable capacity first.

Early Bird was developed from its predecessor *Syncom* by use of a higher-power traveling wave tube and a narrow-beam antenna. These together boost the effective radiated power six times over that of *Syncom.* Solar panel area was increased 50% to provide a 46-watt input power and longer life.

Currently *Early Bird* is at 27.5 degrees west longitude, where it can link ground stations at Andover, Me.; Plemeur Bodou, France; Goonhilly Downs, England; Raisting, Germany; Fucino, Italy; and Mill Village, Nova Scotia.

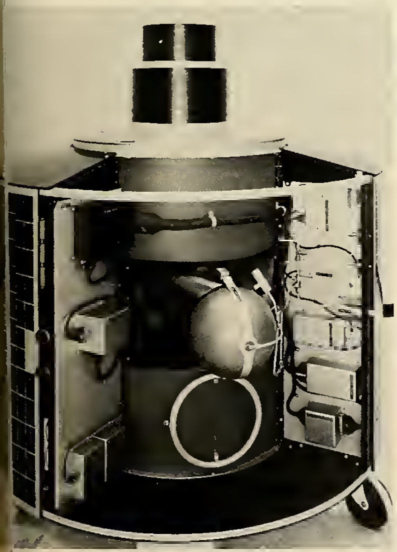
Within two to four years, the positioning control of the satellite will be lost due to decomposition of the hydrogen peroxide onboard fuel. The satellite will then drift slowly westward but could continue to be useful.

New interim system—Comsat's first two-ocean-area coverage is expected to become operational by Sept. 30 this year and will provide circuits for both NASA and commercial-lease use. Called unofficially the NASCOM/Interim Comsat System, it essentially will be comprised of two synchronous satellites, one over the Atlantic and one over the Pacific Ocean, plus an extension of the present ground terminal complex about the globe. Unlike *Early Bird,* the satellite will give access to several ground stations simultaneously.

The system will fill a significant weakness in the space agency's global communications net (NASCOM) by connecting more efficiently and reliably the new *Apollo* Insertion and Injection Range Ships to Goddard Space Flight Center (and thus to the Manned Spacecraft Center in Houston). Also, the satellite relay provides another alternative path for some existing NASA ground stations.

The Pacific satellite will provide 100 telecommunications circuits between Japan (and other Far East users), Hawaii and the U.S. mainland. The Atlantic vehicle will serve to supplement the existing satellite, *Early Bird,* already in position. It has been estimated that with the addition of the new vehicles to the Comsat system, two-thirds of the world can be linked together by space relay of television and telephone.

Much of the development costs for the satellites and new ground stations to support the system, at least initially, will be borne by NASA. Negotiations are underway between the agency and Comsat Corp. for an estimated $20-million-plus three-year contract. The firm already is well along on the program, working under a $6-million, one-year letter of interest.



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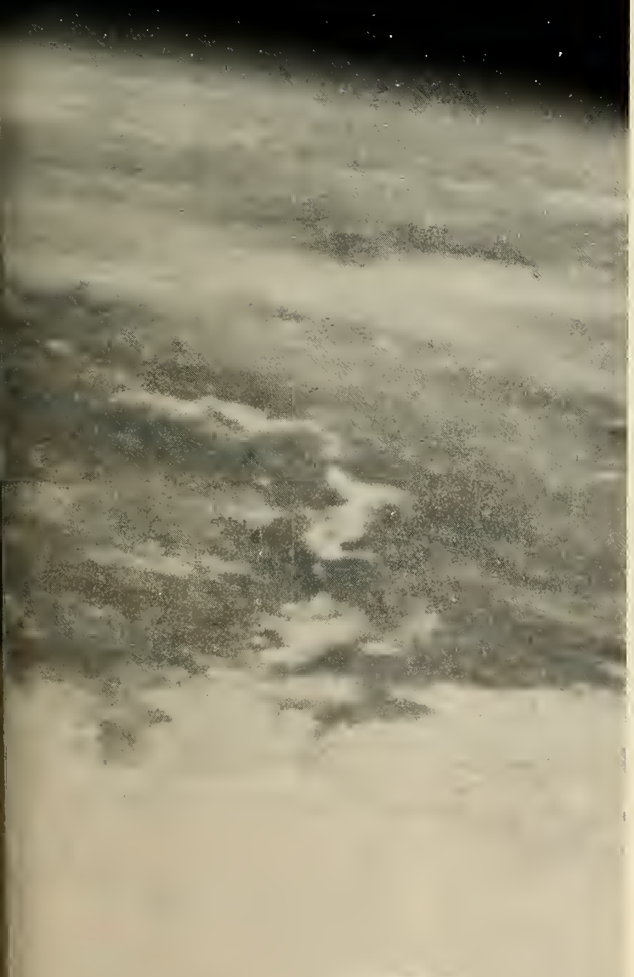

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Philco competence covers the complete space communications system

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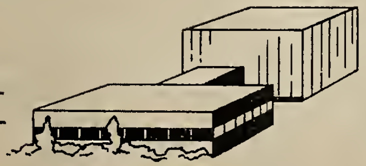

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The only firm to respond to Comsat's RFP for the NASCOM/Interim Comsat was Hughes Aircraft Co. They were awarded an $11.7-million contract calling for delivery of four flight systems within eight months.

With an on-schedule delivery of the spacecraft in mid-July, a tentative first launch has been set for Aug. 19, the second by Sept. 14. When finally moved into their relatively permanent positions, one craft will be located at 170° east longtitude, the other at 6° west longitude.

The Hughes 303A vehicle (excluding antennas and apogee kick motor) will be about twice the size (56-in. in diameter by 26 in. high) and provide three times the power (18 watts) of *Early Bird*.

The basic craft in orbit will weigh 160 lbs.; it will weigh about 340 lbs. at launch. An *Improved Delta* launch vehicle will be used to orbit the satellites. An Aerojet-General 190-lb. Pathfinder will serve as the apogee motor.

The communications package consists essentially of two redundant linear microwave repeaters, using four 6-watt travelling wave transmitter tubes. The repeaters provide a 125-mc bandwidth and have a 6-db noise figure. Normally, only three TWT's will be operated at a given time with the fourth serving as back-up. Two TWT's will serve the NASCOM needs and one will be used for the commercial circuits. However, any combination of tubes can be operated in parallel, depending on the available power. Tunnel diode receivers will be used.

For NASCOM, the system will provide six alternate voice or data circuits and two teleprinter circuits. Data will be handled at 2,400 bits/sec. On an *Apollo* mission, transmission will be directed from NASCOM surface stations to the satellite and then relayed to the U.S. mainland. Inbound, the six voice/data channels will provide one channel for astronaut voice relay, one for spacecraft television, one for high-speed tracking data, and three for high-speed telemetry. Outbound channels will substitute a command load for the telemetry channels. The two teleprinter channels will carry standard 100 word/minute traffic. Should one of the satellite's TWT's fail, the one carrying commercial channels would be switched for NASA use.

Spacecraft receive and transmit bandwidths extend from 6,283 to 6,409 mc and 4,058 to 4,186 mc, respectively. Unlike *Early Bird*, the NASCOM/Interim satellite has an electronically despun antenna which will give broad Earth-surface coverage instead of the squinted beam of *Early Bird*. Antenna transmitting and receiving polarization are linear and orthogonal. Effective radiated power of the satellite will be a minimum of 15.5 dbw, averaged over one revolution.

Global Comsat—Late in the summer of 1968, every country in the world will be within radio reach of the Comsat global network, according to Comsat's technical vice president, S. H. Reiger, with the placement of the global comsats in orbit. The new flight systems will provide 1,200 circuits with a capacity tradeoff of either 900 standard telephone circuits and one black and white TV link or 600 phone circuits and two B&W TV channels (or 300 duplex phone circuits for one TV simplex channel). This will be the first satellite designed from the start as a commercial vehicle.

Comsat RFP's for the global system were released in August, 1965, and three bids were submitted by TRW, Inc., teamed with International Telephone & Telegraph Corp.; Hughes Aircraft Co., and Radio Corp. of America.

In December, the TRW/ITT team was selected as the number-one candidate for contractor and negotiations were started immediately. (Reportedly, the technical response from the winner was extraordinarily detailed; the price range among the three was very narrow.) Target date for completion of negotiations and approval by the international committee is March, 1966.

Total contract value is estimated to be in the $30 to 40-million range, and include nine satellites plus supporting onboard and ground telemetry, command, and checkout equipment. Of the nine vehicles, there will be one prototype, two engineering models and six flight models. First launch is planned for the first quarter of 1968 over the Atlantic Ocean.

The single satellite will replace two satellites providing Atlantic coverage at that time. One of these probably will be jockeyed in orbit to assist in Pacific area coverage, the other to the Indian Ocean area.

All hardware under the TRW/ITT contract is to be delivered to Comsat within 24 months. Design goal is for a 5-year operational lifetime.

One major decision remains to be made by the Comsat international consortium—the orbital (and thus operational) configuration of the future system. A decision must be made within six months after award of the contract (to prevent developmental delay) as to satellite deployment into either synchronous or medium-altitude orbits. By changing the apogee-kick motor, the satellite could be launched into 8, 12, or 24-hr. orbits with inclinations from 30° to 0° In any event, the satellites will be spin-stabilized in circular orbits at whatever altitude is chosen.

Spacecraft structural design will be such that up to six vehicles can be launched simultaneously. Each will weigh 234 lbs. and measure 37 in. high by 56 in. in diameter.

De-spun, Earth-oriented, directive antennas providing at least 10-db gain (and possibly up to 16 db) will be required. Beamwidth will be 20 degrees. A parallel development effort will be performed for both mechanical and electronic de-spin approaches. Electronic despin would be carried out with 16 probes around a circle, phased by ferrite devices.

Two completely independent transponders will be used, each employing a 5-watt TWT. The linear microwave repeaters will each provide a 225-mc bandwidth. Received signals will be in the 5,925 to 6,425-mc band and transmissions back to ground will be in the 3,700 to 4,200 mc band.

If and when a decision is made concerning use of Earth satellites for television distribution, the TRW satellite will be employed, at least initially. If each major U.S. TV network is involved, three satellites probably would be launched into orbit simultaneously—one satellite for each network. The 1,200-circuit capability in the satellite would be equivalent to four TV channels, or three with 300 telephone circuits to spare, depending on the user needs. Three channels are required by the networks as a minimum to provide for each continental U.S. time zone.

Multi-purpose satellite—Follow-on to the currently planned system could be a 1,000-lb. multi-purpose communications vehicle with up to a 6,000-circuit capability. Providing nearly simultaneous access by all users on a frequency/time sharing basis, the spacecraft would also be used for any of several special-purpose communications roles—such as direct broadcast or mobile telephony. Phase-in for such a system advance would be in the late '60's or early '70's, according to Reiger.

An RFP calling for a four-month preliminary-design study for the large satellite was released by Comsat Dec. 28 with 45 days allowed for response to proposals.

Responses are due back to Comsat by Feb. 11. Contracts in the amount of $150,000 to $200,000 are expected to be awarded to two or more bidders. Odds are, insiders say, that there probably will be one U.S. winner and one European contractor. At least 15 to 20 responses are anticipated by Comsat officials.

A highly flexible flight system is envisioned with all electronic subsystems fabricated to a single building-block design.

A synchronous orbit will be the chief consideration for the large craft, which could include up to a 1,200-lb.

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apogee-kick motor. Electronics for the system are well within the state-of-the art, Comsat scientist S.W. Spaulding asserts, but power supplies will have to be given heavy emphasis in the upcoming study. Prime emphasis must be given to solar power supplies, he pointed out, but these are fast reaching the practical peak of their capability. More compact, longer-life, higher-powered systems will be needed. Up to several hundred kilowatts will be demanded by very large communication satellites, and, said Spaulding, the most attractive approach now appears to be with nuclear supplies.

For the first of the large vehicles, however, solar-cell arrays would be sufficient, Spaulding said.

In addition to the problem of power, the advanced satellite is expected to provide VHF and microwave transmissions simultaneously, thus creating a major antenna design problem.

No launch-vehicle problems are anticipated since both *Atlas-Agena* (SLV-3X) and the *Titan III-X* are capable of providing satisfactory launch and injection booster power.

Hughes has been studying a 1,550-lb. stationary satellite that could relay color or black and white TV programs directly to home receivers. Homes would use flat or hidden 6-ft.-dia. dishes costing about $40. Conversion of existing TV receivers for direct reception would cost $100, according to estimates by Hughes.

The future—Applications for the larger class vehicles will be numerous by the 1970's, say Comsat officials. While many of these communications functions can and probably will be handled by interim vehicles, such as the TRW global comsat, the larger vehicles will be more efficient and more flexible in operation.

For example, although one global comsat with its 1,200-circuit-capacity could satisfy the needs of one television network for three time-zone simultaneous transmissions, the advanced vehicle could provide the same service for all major U.S. networks.

Satellite TV distribution, proponents say, offers a means for more flexible, lower-cost operation. Much of the present tape storage and later re-play of programs by the stations could be avoided. Opponents can also point out problems, particularly for the employment of live news event coverage from remote areas. But, Comsat officials suggest that this problem of tying into the network can be handled readily by the judicious deployment of 20 to 30 small transmitter sites throughout the country for relays from the remote pickup point to the satellite.

Other forms of TV distribution services could be offered in time by Comsat, according to Spaulding. For example, a kind of "closed-circuit" TV system could be sustained by the large U.S. universities to present and share expert lecturers, demonstrations, or even surgical operations. Today, said Spaulding, there are at least 1,200 potential users of such a system and, in time, another 800 who could lease the necessary ground equipment to participate. Secondary schools and parochial schools might also be able to avail themselves of such a service.

Air traffic control—By mid-1967, the Federal Aviation Agency probably will employ an interim satellite system equipped to handle VHF for trans-Atlantic jet aircraft traffic control. The system would provide two simplex channels. This is sufficient for satisfactory communications on a time-sharing basis for up to 30 aircraft aloft at one time—the maximum anticipated with the 68 to 70 daily crossings scheduled.

Communications satellites offer the airlines and air traffic control authorities a reliable international en route communications system for voice or data for the first time. Previously, deficiencies in high-frequency communications links have played a large part in preventing use of data links in aircraft.

The airlines want to modify existing equipment as little as possible and therefore prefer a VHF satellite transponder. First VHF tests along this line stemmed from a 1964 meeting sponsored by the Air Transport Assn. and involved representatives from Pan American, Bendix, Boeing, Hughes, Comsat Corp., the FAA, and NASA.

In November, 1964, the first aircraft reception of VHF teletype via a satellite was demonstrated. In January, 1965, teletype was first transmitted from an aircraft to the ground. Both tests were over the Pacific using *Syncom III* and the Camp Roberts ground terminal in California.

Problems encountered were high corona noise in bad weather, signal polarization shifting, and multipath reception from sea water reflections. A side-looking antenna firing through two windows over a wing gave best results with *Syncom III* over the San-Francisco-Tokyo route.

Next tests of VHF aircraft-satellite communications are scheduled with NASA's *Applications Technology Satellite B,* to be launched late this year. It will have a VHF voice communications transponder to provide an FM/FM duplex voice channel. A 30-watt satellite transmitter will operate through an eight-element phased-array antenna with 8 to 10-db gain. VHF range measurements will also be made via this system to evaluate navigation possibilities.

Fixed Earth stations—Comsat has now settled on three fixed U.S. Earth stations at Andover, Me.; Brewster Flat, Wash.; and Paumalu, Oahu, Hawaii. These will serve to complete the U.S. portion of the first global satellite communications system.

The Andover station is the original *Telstar* experimental ground communications terminal developed by American Telephone and Telegraph Co. With slight modification, it was employed with *Early Bird.*

Now leased from AT&T, the station is currently subject of an extended negotiation for outright purchase by Comsat.

The new stations will complete the U.S. portion of the global system and will provide commercial overseas communication between the U.S. and Pacific area facilities. All stations will be capable of monitoring their own signals, receive in the 3,700 to 4,200-mc band, and transmit in the 5,925 to 6,425-mc band. Station capacity will be expanded by increasing the number of antennas. There is room for five antenna systems at the 310-acre Brewster Flat site.

Percentage interest of INTELSAT's 48 member-nations is shown below according to December figures. Quota is derived primarily from estimated international traffic.

Algeria	00.567166
Argentina	01.475607
Australia	02.496228
Austria	00.181544
Belgium	00.998491
Brazil	01.475607
Canada	03.403947
Ceylon	00.047264
Chile	00.295121
China	00.094528
Colombia	00.567166
Denmark	00.363088
Ethiopia	00.075622
France	05.537087
Germany	05.537087
Greece	00.098374
India	00.491869
Indonesia	00.283583
Iraq	00.009453
Ireland	00.317702
Israel	00.593878
Italy	01.996982
Japan	01.815438
Jordan	00.047264
Kuwait	00.047264
Lebanon	00.075622
Libya	00.028358
Monaco	00.004726
Netherlands	00.907719
New Zealand	00.425375
Nigeria	00.350000
Norway	00.363088
Pakistan	00.246625
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South Africa	00.283583
Spain	00.998491
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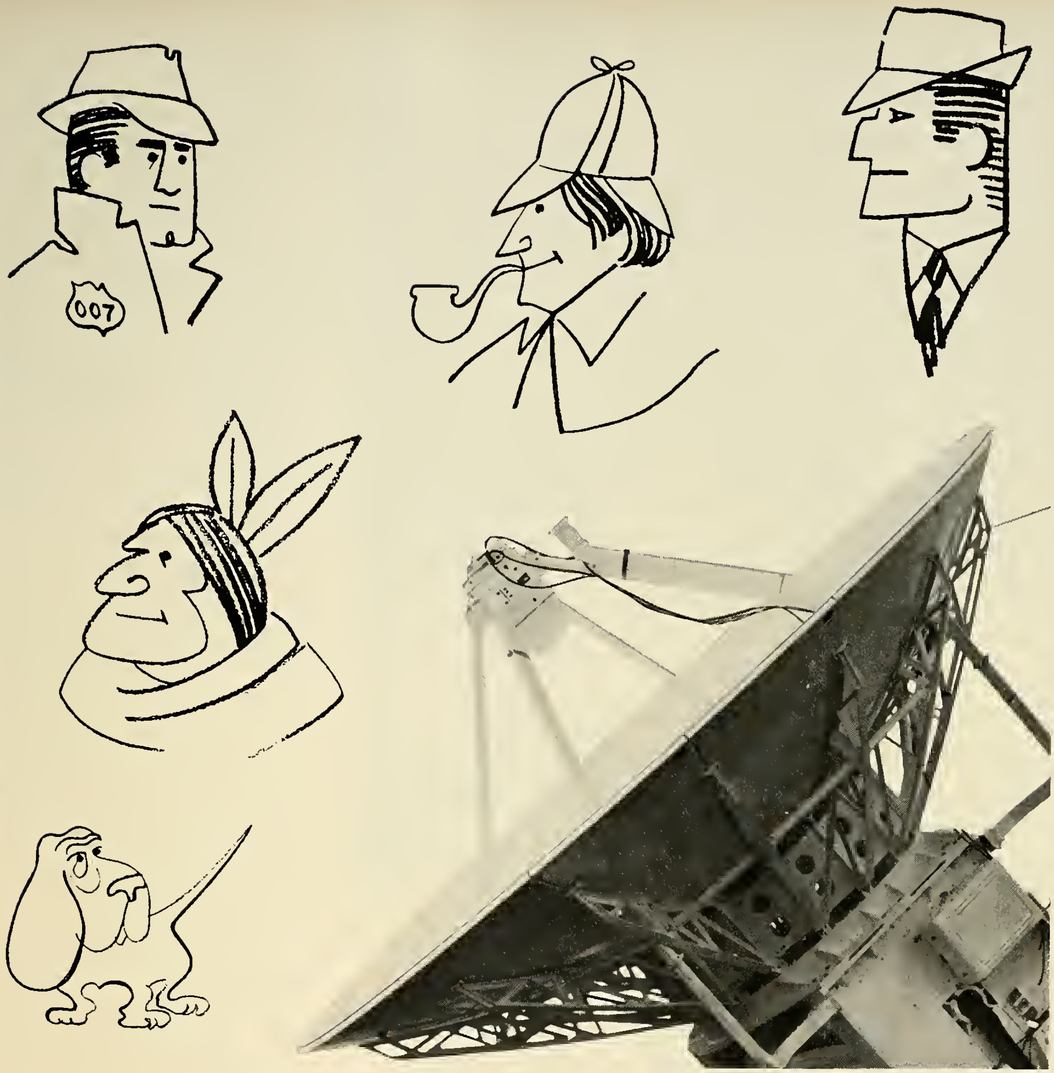
Switzerland	01.815438
Syria	00.037811
Tunisia	00.189055
United Arab Republic	00.330847
United Kingdom	07.624841
United States	55.370870
Vatican	00.045386
Venezuela	01.000000
Yemen	00.029595



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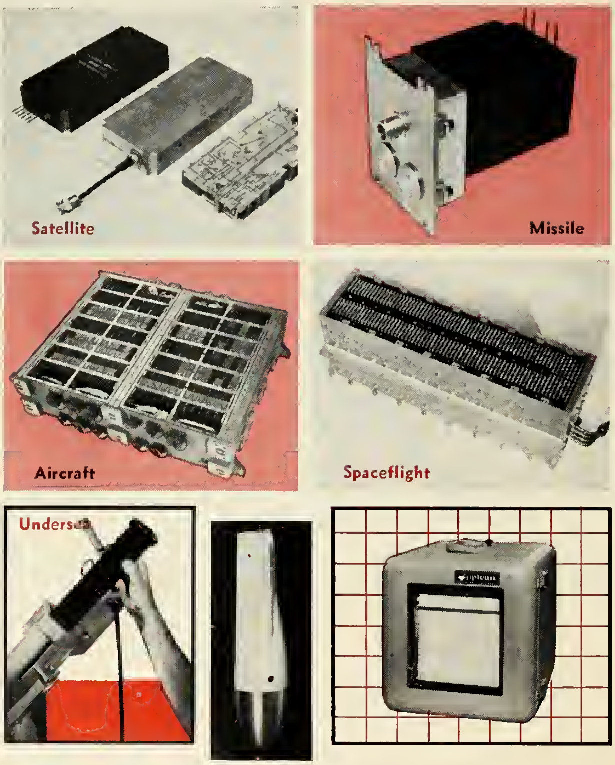
In addition, each station will be able to acquire and track synchronous satellites in azimuth and elevation for all orbital modes and provide look-angle data obtained during tracking.

Vern W. Johnson & Sons, Inc., of Spokane, Wash., was selected in November to build the facility under a $909,382 contract with completion due by June 30 of this year. Early in December, the Paumalu station construction contract, valued at $948,362, was announced with selection of J. P. Finan, General Contractor, of Honolulu. Completion for that facility is also scheduled for June 30.

Because of the longer lead-time needed to permit contractor response, RFP's for the fixed-station electronic equipment were issued by Comsat last August. By December, two major contractors were selected: Sylvania Electric Products, under a $4.65-million award to build and install an 85-ft. paraboloidal-reflector antenna and 100-ft. boresight tower at the Brewster Flat and Paumalu terminals; and ITT Federal Laboratories under a $1.78-million award for the principal ground transmitting, receiving, and tracking electronic subsystems. Delivery, installation integration and checkout of all equipment under these two contracts is due by December.



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An RFP for the basic multiplex equipment in each station was due for issue late in January. No decision has been made yet on the method of interface between the terminals and the telecommunications common carriers.

Major equipment to be provided for each site under the ground communications contract include: for transmitting—two high-power klystron amplifiers (5-kw output) with a diplexer, two FM exciters, two FM deviators, and an option for one command deviator; for receiving—two FM receivers; an intra-facility link, a baseband distribution unit, TV sound and order-wire subsystem, ground communication control unit, test translator, channel monitor subsystem and a polarization-angle subsystem.

Down converters will be located in the feed cone and all transmitting equipment will be located in a separate shelter adjacent to the base of the antenna tower.

Dual capability—The major function of the ground communications equipment will be to provide a dual capability for operation with the global comsats, either on a single carrier with standby or with two carriers simultaneously. Design will allow either half of the dual system to operate on either assigned carrier and it will be possible, with up to a 30-mc separation, to transmit both carriers through the system with either exciter/power amplifier combination.

Frequency response of the system will be 30 cps to 5 mc (±0.5 db) for video and 300 cps to 5 mc (±0.5 db) for multi-channel telephone output.

The 85-ft.-dia. dish will employ a Cassegrain feed and will include an integral maser-type low-noise pre-amplifier receiving subsystem. An elevation-over-azimuth type mount will be used. The design, according to Comsat officials, will assure a 15-year operating life without need for a protective radome.

Pointing accuracy of the big dish will be to 0.04° and tracking accuracy to 0.02° in 30-mph winds (average). The mount will permit continuous azimuth rotation and elevation rotation from −2° to 92°.

The feed cone of the antenna will carry the entire feed system, communications and tracking preamplifiers, down converters, and the RF portion of the test translator.

The maser amplifiers will be designed for a 10°K maximum noise figure and provide a 30-db minimum gain over the entire operating band. Cryogenic cooling will be employed.

Transportable terminals—For NASCOM, Comsat has awarded a $4.5-million contract to Page Communications Engineers, Inc., for three transportable ground stations. These will be set up at Andover, Brewster Flat and Paumulu and should be in use by September, 1966—before the 85-ft. antennas are operational.

Six other terminal stations, all with small antennas, will take part in the NASCOM network. Three will be U.S. government stations to be erected on ships in the Indian, Atlantic and South Pacific Oceans. The others will be at Ascension Island, Grand Canary Island, and Carnarvon, Australia, and will be built by the United Kingdom, Spain, and Australia.

The Page stations will each have a 42-ft. folded horn reflector with monopulse feed and an elevation over azimuth pedestal. Each station is designed to provide 14 voice/data channels for the *Apollo* satellite when operating in a multi-carrier mode.

Using one NASCOM satellite transponder with an effective radiated power (ERP) of 6 watts, the station will provide a 24-channel capability with an improved weighted signal-to-noise ratio. Expansion to 100 channels is possible, using the full satellite capability.

Each ground station can radiate a single carrier with an ERP in excess of +95 dbw.

The antenna auto-tracks or program-tracks medium and synchronous altitude satellites. From the satellite and the station antenna, the station can extract angle tracking data, range data, feed polarization angle and satellite telemetry.

Each station is housed in four main packages: operations van, antenna complex, maintenance van and power van. The facilities are designed to operate from —30° to 125°F and survive winds of 120 mph. Full operation and tracking can be carried out in winds of 60 mph.

Low-noise feed for the antenna is being developed by Radiation Systems, Inc., under contract to Page. It will provide three-channel monopulse outputs in the 4-gc receive band and an on-axis beam function for the 6-gc transmit band.

Either one of the dual 12-kw transmitters, tunable from 5,925 to 6,425 gc, can be selected by remote control. The front end of the dual receiver subsystem is made up of two stages of parametric amplification, with a common pump and a tunnel-diode post amplifier. Helium closed-cycle refrigeration is used. Down converters change the incoming signal frequency from 4 gc to 70 mc for communications and 136.5 mc for telemetry. Receivers and converters are also furnished in dual to provide either instant backup or simultaneous reception from two remote ground stations. System noise temperature is 85°K at an elevation angle of 5 degrees.

Comsat has an option to purchase two additional stations. ■

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PART III: MILITARY SYSTEMS

Tactical Comsat Network Planned

DDR&E awaits recommendations from services; RFP to industry expected soon; extensive new hardware development anticipated

by Michael Getler

Hughes 6-ft.-dia. shipboard antenna has successfully provided communications via Syncom III in the Pacific. One two-way voice channel is accommodated.

WITH LAUNCHING of the first eight-satellite portion of the Initial Defense Communications Satellite Program (IDCSP) about two-three months away, service and Defense Dept. planners are already laying the groundwork for a new satellite network designed specifically to meet the growing demand for tactical communications.

At the request of the Director of Defense Research and Engineering (DDR&E), all three services late last year began developing a coordinated plan that could serve as a basis for recommendation regarding future development of a tactical communications satellite program. This plan is expected to be submitted to DDR&E within the next several weeks. First requests for industry proposals to support this effort are expected in about five months.

Although the project is still only in the formative stage, there is already considerable enthusiasm for it among all the service and DOD agencies concerned and also within the Joint Chiefs of Staff. Application of satellites and advanced ground terminal equipment to this area of communications will require extensive new hardware development and management analysis. However, its potential for solving an increasingly complex and demanding facet of military communications is easily recognized.

A great deal of the enthusiasm for use of satellites to aid in tactical communications springs from the fact that a tactical system, by definition, involves many users directly involved in combat. Support for its development, therefore, extends through a very large segment of the U.S. military. Experience in Vietnam, which has highlighted very clear new requirements for tactical communications, has added to this support.

It should be stressed, however, that use of satellites to support *all* forms of secure military communications, both tactical and strategic, is looked upon with great expectations by the services and DOD. Agreement upon this point is unusually widespread.

As matters now stand, there are

three major military communications satellite projects under way, although the stages of development vary greatly. These include:

—*The Initial Defense Satellite Communications Program (IDSCP)*—A 24-satellite system slated to be placed into near-synchronous-altitude orbit in three eight-satellite launchings aboard the Air-Force's *Titan III-C*. First launching is expected this spring, probably in mid-March.

The IDSCP is a research and development project, but it involves a complete global comsat network—the first of its kind—and will provide DOD with unique experience in global comsat systems management. Once its R&D role has been completed, the system will be turned over for whatever operational service it can render. IDSCP is viewed essentially as supporting a strategic communications requirement; this will mean (in a fully operational net) a few channels able to continuously carry a comparatively large amount of data to a few users—all at high command levels.

—*Advanced Defense Communications Satellite Program (ADSCP)*—Basically an advanced strategic comsat link intended to support operational requirements. It is expected to go into operation roughly three years after the IDSCP begins to function and is expected to reflect much of the experience gained with the initial system and the electronics technology developed since 1962, when the IDSCP hardware effort began.

This system is now in the study phase, with six firms holding contracts from the Defense Communications Agency (DCA). DCA is the agency responsible for development and operation of both IDSCP and ADSCP.

—*Tactical Satellite Communications*—Not yet an approved program, but definitely on the way. Development responsibility falls within DDR&E, not DCA. Operational control is not yet defined. This type of network is viewed as different from the strategic systems in that it will involve small amounts of data to possibly thousands of users.

In support of all three of these programs, there is an extensive development effort for both fixed and mobile terminal equipment for use on land, ships, aircraft, vehicles, and even with individual soldiers. It is within this area that more technical innovation is called for than is needed in the space segment. The market for terminal equipment will be enormous and the competition is already extensive.

In addition to the major programs already mentioned, there are several others making important inputs to the development of military comsats. The company sponsored private efforts number in the dozens.

A more detailed description of the

Above: True transportability is achieved with the Army's AN/TSC-54, now under development by Radiation, Inc. Cloverleaf construction reduces weight markedly. Below: Mascot terminal developed by Philco WDL has 15-ft. reflector and provides four communications channels. System is air-transportable.

principal satellite and ground terminal projects follows.

IDSCP

Although IDSCP will provide the military with a unique capability to gain experience with a complete network, DOD planners are quick to admit that the system has many shortcomings, that its capacity is "lean," and that it is built using 1962 technology. Even in its operational phase, which will probably come at the completion of R&D testing in early 1967, planners stress that it is "not the type of network upon which combat plans would be based."

Launch schedule—Under current plans, three *Titan-III-C* launchings, beginning this spring and then spaced roughly two months apart, will each carry eight 100-lb., Philco-built satellites into a random, 18,300-n.-mi.-high, equatorial orbit. The satellites are deployed from the *Titan III-C* Transtage with relative velocity differences between 5 and 10 fps, which, according to DCA estimates, will provide the intended global dispersal in less than 100 days.

The satellite is spin-stabilized and will operate at X-band (8 kmc receive/7 kmc transmit) using a frequency-translation repeater. The repeater will house redundant long-life traveling-wave tubes, each able to provide roughly 2.5 to 3 watts output to the antenna system. The antenna is a circularly polarized, bi-conical array, with about a 25-degree beam width, shaped so that its torroidal pattern continuously illuminates the Earth as the satellite spins.

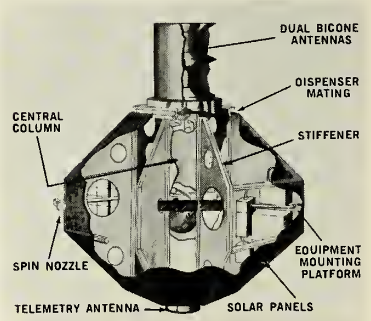
The satellites are designed for three years of performance, and require no command and control circuitry. This latter omission is a common one for many military spacecraft to avoid enemy tampering either with the satellite's data or position-keeping equipment. Although position-keeping at synchronous altitude has already been demonstrated, the requirement for a ground link to initiate the correction both complicates the satellite's onboard electronics and leaves the craft vulnerable to enemy tampering with its position.

However, a self-contained, on-board station-keeping system that could function independently of ground command is a stated military requirement and probably will be explored as part of the continuing Lincoln Laboratory experimental comsat series.

Not synchronous, but—The IDSCP compensates for the location advantages inherent in a truly synchronous altitude system, in which the satellite position appears to remain fixed, by using a large number of relatively simple satellites in the near-synchronous equatorial orbit. In this manner, the entire system drifts about 30 degrees per day, so that individual satellites stay in view for about 4½ days from a 35-degree latitude, for example, and all satellites will drift past a given point on the Earth at about the same rate.

The IDSCP is intended to provide the highest degree of visibility at the earliest post-launch time to the two East and West Coast entry links in New Jersey and California.

In addition to operating experience, the IDSCP has also brought about one of the first satellite production lines in the industry's history, with 24 units now on the line at Philco's Western Development Laboratory Div. Depending on the final number to be produced, including some backups for a scheduled replenishment launch, Philco's effort on the program is valued at between $30 and 50 million.



Twenty-four satellites of this type will be used in the Initial Defense Satellite Communications Program. The satellites are spin-stabilized.

Besides satellite production, Philco has a separate contract for development of the control center at DCA for the IDSCP. The equipment includes principally data and status displays. There will be no computer used, and DCA officials say the control room will be essentially manually operated and used for network scheduling. It will be manned during the R&D phase by the Army and then by DCA. Existing control centers in DCA European and Pacific theaters will also be linked to the IDSCP.

While DCA acts as the principal customer and manager of IDSCP and ADSCP, the actual development and procurement contracting functions are performed by the individual services. The Air Force's Space Systems Div. is responsible for the space segment of the program, with the Army's Satellite Communications Agency responsible for the ground terminals. The Navy's shipboard terminal development is the task of the Satellite Communications Project Office in the Bureau of Ships.

Other experiments—Within the four scheduled launchings for the IDSCP, including the replenishment launch that should come in about one year, there are several other important comsat experiments. Combined with the operational experience gained with IDSCP, these will form the basis for making decisions on the ADSCP.

They include a gravity-gradient comsat stabilization experiment and a new de-spun antenna.

The replenishment launch will, in itself, provide valuable experience regarding how best to accomplish this phase of network maintenance.

The gravity-gradient experiment will be flown aboard the second IDSCP launch. It will be a two-axis system, built by General Electric Co. The satellite that carries it will not contain a communications subsystem. The unit is intended as an aid to evaluate potential for gravity-gradient at the near-synchronous altitude. The pros and cons of this technique will have a great bearing on the final antenna system/stabilization technique chosen for ADSCP.

In addition to the two-axis system, a Navy/Johns Hopkins University three-axis gravity-gradient system is also expected to be flown aboard one of the later *Titan III* R&D boosters, probably number 14.

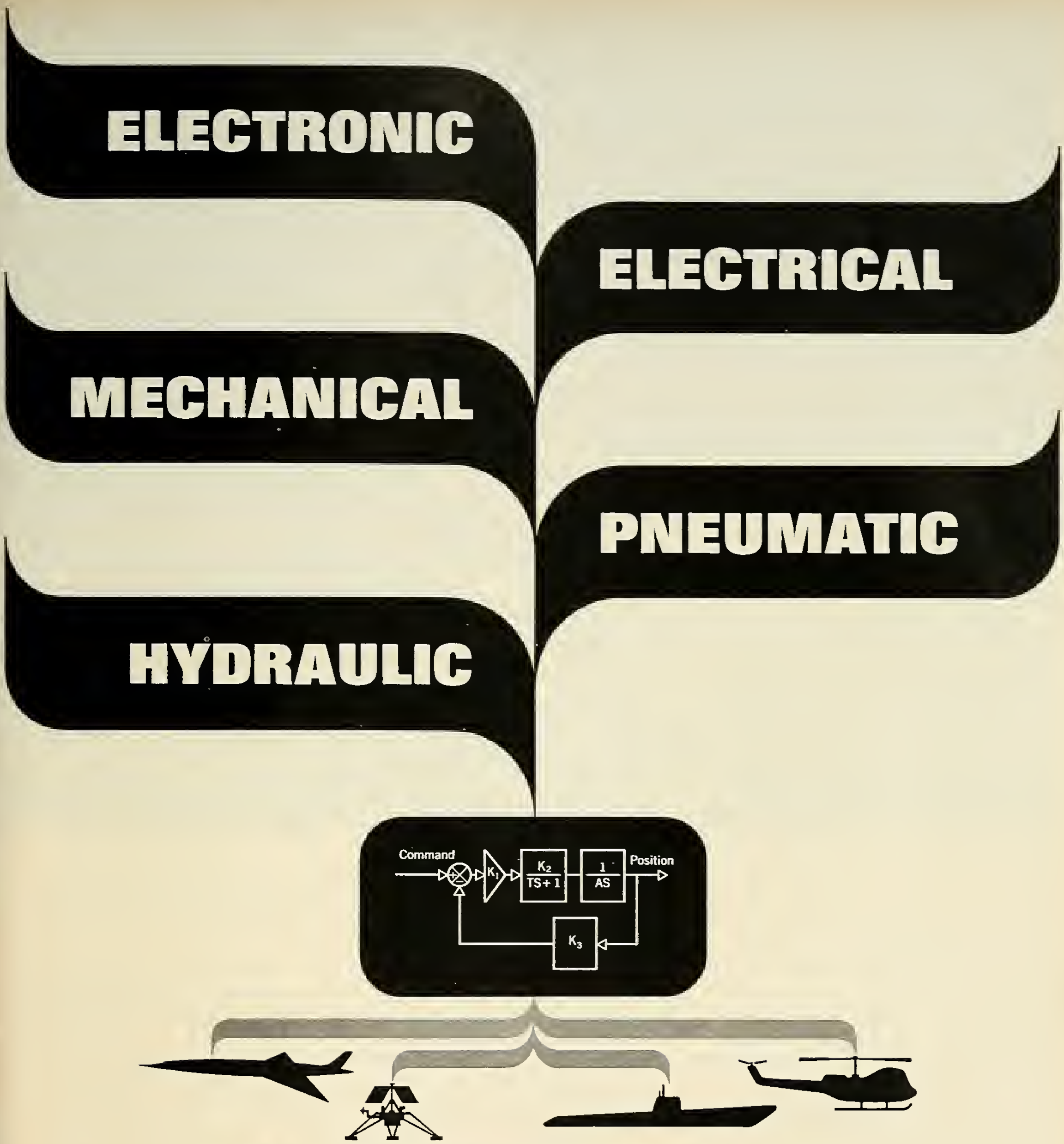
The antenna experiment involves an electrically de-spun system developed by Sylvania scheduled to go aboard the replenishment launch.

While not in the IDSCP launch sequence, the series of Lincoln Lab satellites (*LES*) has also tested a new antenna switching system that appears to offer considerable promise and may well prove to be a competitive concept for the ADSCP.

UHF satellite—To help evaluate potential for UHF comsat links, in comparison to microwaves, DDR&E planners expect to place a 100-watt UHF repeater satellite aboard one of the remaining *Titan III* R&D vehicles. It will probably be part of the *LES* program. Operation of this satellite and of the ground and airborne equipment with which it will communicate could have a dramatic effect upon the entire future of military satellite communications.

The reason is simple: the armed forces all have a substantial inventory and investment in UHF communications equipment. To be able to amortize this equipment further by making use of it in a satellite link, rather than developing an entirely new family of ground/air terminals, would be a major savings.

Despite this apparently strong point in favor of UHF, there are not many highly placed comsat planners who believe it will work well enough over long path lengths to replace the microwave system. It is also pointed out by some designers that much of the UHF equipment now in use is relatively old and that considerable new investment would still have to be made to refine existing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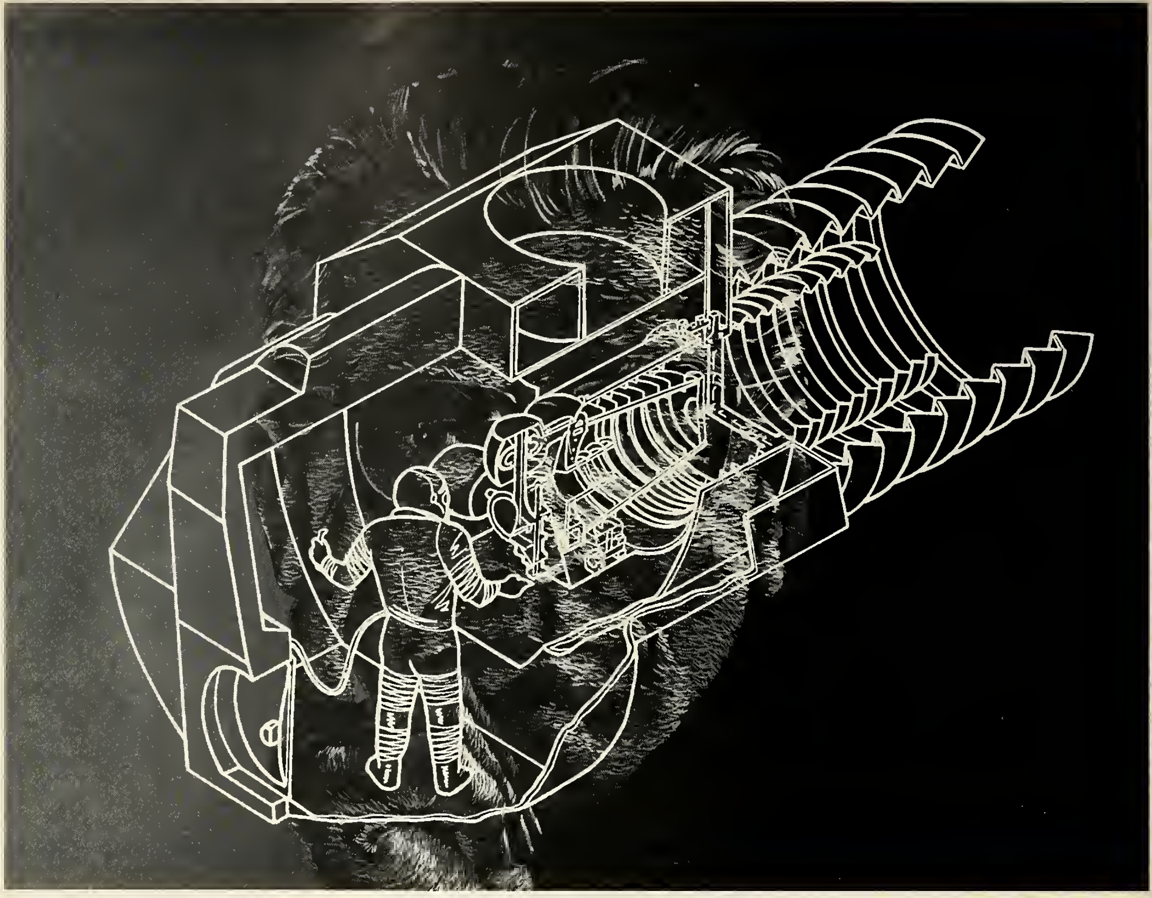

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equipment and redesign antennas so that they look in the right direction.

The UHF satellite will help define the reliability of the communications path, noise patterns, aircraft receiver problems, and other potential bottlenecks.

Flying antenna lab—Because the problem of aircraft receiving equipment for use with comsats is considerably complex, regardless of frequency, the Air Force has begun putting together a complete flying laboratory, housed in a C-121, to carry out experiments relating to this problem. In addition to use of satellite nets for tactical or strategic aircraft communications, it is also assumed that much of the future command and control will be from airborne platforms.

The airborne lab experiments will include studies of various antenna designs, size vs. weight tradeoffs, noise factors imposed by other operating equipment, polarization control, antenna directivity control, protrusion from the airframe, power handling problems, and potential power breakdown difficulties at high altitudes.

Terminal types—In support of IDSCP, the Army and Navy will move into the field and aboard ship three new types of comsat ground terminals. In addition, existing antennas originally developed to support the Army's ill-fated *Advent* program are also being modified to support IDSCP. IDSCP is expected to operate with more than 20 separate terminals.

The market for ground terminals in support of all future military comsat nets is "of an astounding magnitude," say Army officers.

Many observers believe that enthusiasm for comsats once they are demonstrated in the IDSCP is apt to upset even optimistic estimates of the total market for ground equipments. There is little doubt that firms already holding contracts for IDSCP units are in an excellent position for follow-on awards in support of operational systems. It is the current intention to use the IDSCP-type terminals for the ADSCP, with modular type improvements.

A whole new family of terminals will be needed for tactical systems, a task already taxing the industry's talent.

DOD will insist on far more reliability in surface terminals than has been demonstrated. No longer will mean-time between failure (MTBF) histories measured in hours be suitable, say DDR&E officials. Satellite lifetimes measured in years, with little attention paid to the lifetime of ground systems, will have to be sharply altered, they say, especially in light of remote strategic or contingency operations, and certainly where tactical units are involved. There will also be major DOD pressures to bring the unit cost of these terminals far below the current figure, which averages about $1 million per copy.

Specific systems—For IDSCP, the following systems will be put into operation.

The two 60-ft. antennas—one at Fort Dix, N.J., the other at Camp Roberts, Calif.,—originally built for *Advent*, are now being modified to serve with IDSCP. Frequency changes, improved receivers, and new modulation/demodulation equipment are being added. These AN/FSC-9 terminals will serve as the so-called "gateway" links to the mainland from eastern and western global operations.

Developed specifically for IDSCP are three systems: the Army's AN/MSC-46 and AN/TSC-54, and a new shipboard terminal for the Navy.

The Hughes-built AN/MSC-46 is a 40-ft. semi-fixed but transportable terminal housed in three vans, plus additional power equipment. Hughes is supplying eight of these terminals to the Army under a $12 million R&D and procurement program. The first two systems have been delivered. The first unit is being used for training purposes, but the other units are expected to be deployed outside the U.S.

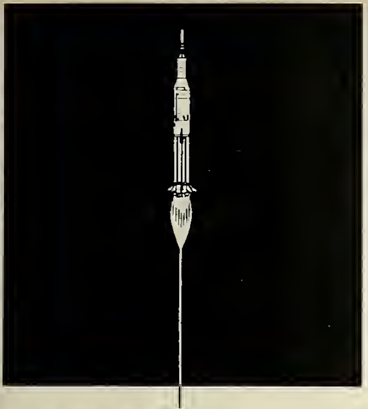
Army officers report that a new 40-ft. dish is also going into Saigon to replace a smaller, 15-ft. antenna system that had previously been used for experiments with the *Syncom* satellite. These *Syncom* experiments have been highly successful and have proven that the anticipated problems caused by time delay are in fact no problem to military users. Much of the delay difficulties have been avoided through use of the so-called four-wire receiver system.

The MSC-46 is not truly mobile, according to the Army, although its designation implies that it is. It will provide two high-quality duplex voice channels, or perhaps five channels with reduced quality. Addition of digital data processing equipment at the terminal will allow up to 16 duplex vocoded voice channels.

Concern for security—There is heavy emphasis throughout all military comsat programs on the development of digital modulation and demodulation systems as the principal means to insure secure coded voice communications, combined with new onboard digital processing systems for the satellites.

The Army's AN/TSC-54, now under development by Radiation, Inc., under a $9.2 million contract, comes much closer to a truly transportable station. The unit, designed to quickly support overseas contingency operations, employs a nominal 15-ft. antenna in the form of a four-dish "cloverleaf" array.

It is designed for use with the ADSCP. Each terminal, according to DCA engineers, is capable of providing one tactical quality duplex voice chan-



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nel, four vocoded voice channels, and up to 64 duplex telegraph channels "with the appropriate terminal equipment."

The system is divided between two trailers, with a total weight, including fuel for 72 hours of operation, of about 10 tons. Each complete terminal (with six operators) can be transported in a single C-130 aircraft and can be set up within two hours. The antenna system uses a new dielectric feed to greatly reduce side-lobes and hence improve anti-jam capability. The firm is supplying 12 units.

The new Navy shipboard terminal is also being built by Hughes. That firm provided the Navy with its first two 6-ft. dish antenna systems, installed on the USS Canberra and USS Midway in late 1964 for experiments with *Syncom*. These experiments worked well, and the Navy remains highly interested in satellites as a way out of the continuing difficulties with conventional long-haul HF communications.

The new Hughes antennas, the first of which will be delivered in about five months, will be the same size as the earlier ones, but will reportedly be much lighter. The systems will have a 5-kw output power. The gyro-stabilized antenna will be mast-mounted and towable.

The Navy expects to test the system initially aboard large combatant vessels, although officers feel it is probably possible to operate them now with destroyer-class vessels. Seven terminals are being procured.

Competition for mast and below-deck space has forced the Navy into a major effort to reduce the size and weights associated with shipboard terminals, particularly to allow use with submarines. There is an acknowledged difficulty in getting the size below 6 ft. The answer may come from improved satellite performance.

The Navy's shore terminal requirements will be filled by developments undertaken by the Army.

Other candidates—In addition to these three terminals, already designated for IDSCP and probably ADSCP use, there are several others under development by industry that have attracted service interest. Army and Air Force interest (and some plans for testing) is reported in Sylvania's new ground terminal system, a mobile, 4,000-lb., 12-ft. dish unit. The terminal can be landed by helicopter. There is also said to be interest in a new Philco Western Development Lab air-transportable terminal called "Mascot."

Mascot has a 15-ft. reflector and is being developed on company funds. Intended for IDSCP, it goes with its crew into a C-130 and can be set up and operating in two hours. To achieve lightness, Philco had Varian develop a 5-kw hybrid-cooled klystron that uses only one gallon of recirculating water. The antenna has automatic tracking and makes use of a Micromega-cooled paramp to achieve a receiver noise temperature of less than 80 degrees. Four communications channels are available.

Within three years, Philco WDL expects to have developed a new highly mobile ground terminal, "PET". This will make extensive use of microminiaturization, give a digital communications capability, and be carried by one vehicle. It will have 3- and 6-ft. antennas

ADSCP

The advanced strategic comsat net will evolve out of several programs now under way. These include the operational experience gained with IDSCP, a series of industry studies, an across-the-board R&D program in advanced electronics, and techniques developed in the *LES* program.

The six firms that made original three-month systems-definition studies under DCA contract (Philco, GE, Hughes, Comsat Corp., TRW, and RCA) submitted their results to DCA last month. These results will be reviewed by DCA and by other specialists from the university and non-profit sector during the next several months. DDR&E officials expect that the ADSCP program "will begin to coalesce within the next 6-12 months."

DCA officials say that there "may be some synthesis of proposals" and that by mid-FY '67, ideally with several months of IDSCP operational experience, contract-definition studies for a specific system will go to industry from the cognizant service agencies. Current planning is based on a 1969 launching. Cost of developing the satellite is placed at between $10 and 20 million.

Since ADSCP will support the National Military Command System, inputs to early studies have already come from the Joint Chiefs. It is generally known between what points communications will be required at the high command level, and with development of transportable ground terminals, other contingencies can be supported.

System characteristics—While details are far from settled, this much can be said about ADSCP. The satellite will be rugged, in terms of its resistance to physical attack, and secure, in terms of its resistance to electronic jamming. It will no doubt be a near-synchronous or truly-synchronous altitude system.

There is virtually no talk of lower-altitude systems among planners at this point, however DDR&E officials do not rule out this possibility completely. They point out, for example, that with the *Titan III-C* and a very simple, lightweight, low-power satellite, it might indeed be possible "to build your own ionosphere," using perhaps more than 100 of these satellites per launch.

The requirement to protect ADSCP from anti-satellite attack strengthens the argument for at least the 18,300 n. mi. altitude. "It becomes difficult and awfully expensive at this altitude for an enemy to take these satellites out one at a time," a DCA official explains.

Despite experiments with HF and other portions of the spectrum, ADSCP will probably turn out to be an X-band microwave link, again with advantages over HF in terms of avoiding blackout common to HF during a nuclear explosion. Even at microwave frequencies, however, a nuclear explosion is apt to cause a 10-sec. disruption in communications that would call for resynchronization of cryptographic equipment.

Air Force engineers say there is a small amount of work going on in the application of the millimeter wavelengths for satellites, "but nothing really significant." Engineers see only a dubious gain in directivity at these frequencies in exchange for several hardware and operational characteristics that would raise system complexity and risk. They believe a jump from X- to K-band systems might be reasonable, but doubt the wisdom of using millimeter systems. This view of millimeter usefulness is not shared by many in industry (M/R, Sept. 7, 1964, p. 38).

Although the IDSCP satellite will put out at best 3 watts, the ADSCP will still not be classed as a high-power output, with perhaps a maximum of 18 watts output. Final power profile will depend greatly upon improvements in ground terminal receivers and in the number and type of channels required.

Because of the requirement for the satellites to operate in an electronic jamming environment, the actual capacity of the data system will be reduced, says DCA, to allow inclusion of countermeasures.

Ground equipment characteristics—Out of the work in phased-array and other directional antennas, DCA officials see antenna gains over the IDSCP-type system ranging from 13 to 16 db, depending largely upon the combination of antennas with stabilization schemes.

DCA officials also lay great stress upon the room for technological improvement in the ground terminal area for ADSCP and beyond. In particular, they see need for refinements in parametric amplifiers as the key to better receiver performance. Much of this would be tied to a long-foreseen need for better, higher-capacity closed-cycle cryogenic equipment.

Several new array concepts being pursued could lead to reduced antenna size and noise temperatures, with increased multiple satellite tracking ability.

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ments, currently ranging upward from 5 kw, need to be cut to below 1 kw to aid in achieving mobility, DCA spokesmen say.

TACTICAL SATELLITE COMMUNICATIONS

It is not yet clear exactly when satellites will be applied on a large scale to tactical communications, but this use of comsats is certain.

Backing for the project, combined with the expansion of war in Vietnam and with experience gained in bringing the IDSCP to fruition, could shorten the development cycle for a tactical comsat program, if approved.

Some service and industry planners believe a system could be in operation within three years, but not before two years. DDR&E officials generally do not share this view. Planners there say that even with the potential for shortening the development cycle, a complete tactical satcom system could not be in service until 1970 at the earliest.

First industry activity in support of a tactical system is expected in about five months. The Air Force, under current estimates, at that time will ask for proposals for either detailed systems analysis or development of the spacecraft.

DDR&E project officials believe it likely that a variety of satellite designs operating with a fairly large complex of potential ground equipments will precede evolution of an optimum system. Planners say that it might be mid-1968 before an actual decision could be made to go ahead with a specific type of system.

ADSCP influence—ADSCP design could also affect a tactical system. Some designers believe that development of a broad-bandwidth satellite for ADSCP could be modified to make use of that bandwidth by dividing it into many more narrow channels for use in a tactical situation.

Opinion on satellite altitude presently favors the full synchronous altitude orbit.

DDR&E officials stress what they describe as the "really revolutionary" manner in which the tactical system is evolving, with an insistence from DOD that all three services start out together on the new satellite system.

Service and DOD planners feel that the multiple-access requirement to support many users, each having "comparatively little to say," is now within the comsat state of the art, and that the most perplexing problems will come on the ground, particularly in the need for terminal equipment in aircraft, helicopters, with the field army, and in submarines.

It is also expected that because of the ground problems DOD will attempt to shift the emphasis on complexity back to the satellite, reversing the manner in which earlier comsat designs have evolved.

Army's size constraints—The Army's problem is particularly acute. Operating under foliage, from jeeps, or from individual man-packs is envisioned, in addition to equipments suitable for larger vehicles or stations.

For the man-pack or jeep-mounted unit, Army officers state flatly that no company has yet been able to lick the antenna size problem. Inflatable antennas are said to be no good for use in jungle terrain, especially where vehicle movement is required.

The Army wants to reduce antenna size far below the 6 ft. diameter to make it integral with a soldier's pack. However, they point out that dishes less than 6-ft. will not normally support a single voice channel, and it is a voice requirement that the Army has. Because of this, the Navy's efforts in getting antennas less than 6 ft. for data traffic may not be of much help to the Army.

There is also a major effort under way to reduce the size of the power pack accompanying this equipment. Improvements in satellite power and receiver sensitivity are greatly appreciated by the Army.

The studies that will get under way this year will include analysis of management responsibilities for a tactical system. The ship-to-ship, or small-vehicle unit entry into the system does not lend itself to DCA-type management, and that agency is expected to play only a minor role in development and operation of the system. More likely is some sort of theater- or individual-unit commander management of system segments.

LES/LET program—Four *LES* satellites have been launched by the Air Force thus far, but three of these have all suffered at the hands of malfunctioning *Titan III* subsystems. Only one, however, *LES-1*, was unable to perform most of its mission.

LES is basically an Air Force space technology effort aimed at improving the service's overall competence in the area of its responsibility. The program's primary and most noteworthy achievements have come in the development of new antenna-switching techniques, the application of solid-state technology to X-band transmitters, and the development of some very promising digital modulation and demodulation schemes.

The antenna system consists of eigh narrow-beam horn antennas that illuminate the Earth sequentially as th satellite spins. The satellite also carrie a pair of Earth- and Sun-seeking optica sensors, the outputs of which are use to continually switch the antennas s that only the one facing the Earth is transmitting. This electronic de-spinning operation compensates for the physical spin of the satellite. The de-spun antenna was first tested on *LES-1* and *-2*, but the *LES-4* system used new higher-gain and directional-horn antennas.

LES-3, launched last December aboard a *Titan III-C*, made the first test of a UHF calibration device for comsat purposes. The next *LES* satellite, the fifth in the series, is expected to be the UHF repeater experiment previously mentioned. Beyond this, the Air Force has asked Lincoln Labs in its sixth and seventh satellites to examine the possibility of self-contained station-keeping systems for the satellites at the near-synchronous altitude.

With *LES-2*, Lincoln Labs began experiments using a new Lincoln Experimental Terminal (LET). Emphasis again has been in the digital processing area, and the terminal has thus far operated successfully with *LES-2* and *-4*, and its results encourage both the Air Force and DOD. Also, the new modulation techniques are expected to be incorporated in the Army's 60-ft. antenna system at Camp Roberts, Calif.

LET details—LET, according to the laboratory, contains the first completely digital signal-processing system in a functional communications terminal. This system includes a compact, new dual-mode vocoder developed at Lincoln that provides a 4-to-1 reduction in the required bandwidth while preserving intelligibility and voice quality; the first functional application of sequential coding and decoding (SECO); and a modulation system which, in combination with SECO, is resistant to interference and permits its multiple-access capability.

A small general-purpose digital computer is used to point the antenna and track a communications satellite in a known orbit, to multiplex and demultiplex one (digital) voice and two teletype channels, and to compensate for Doppler frequency shift and time delay produced by the satellite motion.

The 15-ft. antenna uses a Cassegrainian configuration on an azimuth-elevation mount. Designed to operate in winds up to 35 knots, the antenna system can operate in an automatic tracking mode, or under computer control. LET can transmit and receive one voice channel and two teletype channels simultaneously.

MOL communications—Air Force Space Systems Division is procuring equipment that could function as the main communications system for the *Manned Orbiting Laboratory*. This is the space ground link (SGLS) subsystem, which appears to be an attempt to standardize the telemetry, tracking and control functions for all Air Force spacecraft.

The system can carry voice communications and is reported to have a very high digital bit rate.

The spacecraft equipment is a black box of modular design, using integrated circuits, hybrids, and bookform construction. TRW Systems Group has the responsibility for putting in the ground stations for SGLS. ■

Passive Satellites Studied for Backup

PASSIVE satellites are no longer receiving consideration for commercial systems. For military purposes they are relegated to a minor role, chiefly serving as a final backup in the event that active satellites are rendered inoperative. Most reliable satellite for this purpose appears to be the Moon.

Lockheed Electronics is providing equipment for about six ships to enable communications to be maintained by bouncing signals off the Moon.

The contract, placed by the Navy's Bureau of Ships, calls for a capability of ship-to-ship and ship-to-shore communications via the lunar surface.

Shore antennas are probably the 60-ft. size. Shipboard antennas are 16 ft. dishes carried on X-Y mounts.

Dalmo-Victor Inc. is supplying the antenna and pedestal. There is no autotrack feature. The system tracks according to lunar ephemeris that are inserted in advance.

Philco's Western Development Lab has a study contract from the Army's Satcom Agency at Fort Monmouth, N.J., for a universal link terminal intended to provide communications via active and passive satellites, including *Echo* balloons, needles, or the Moon. It is expected to provide a quick reaction to meet changing conditions in strategic communications and is intended to be aircraft transportable.

Deployment time is specified as 8 hours, using 10 men. It will back up major Defense Communications Agency networks, providing a channel capacity that can vary from a major trunk link to a teletype channel via the Moon.

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Digital Links, Millimeter Waves Studied

Future emphasis also to include adaptive antennas as means to direct home broadcast; synchronous satellite considered basic

by William S. Beller

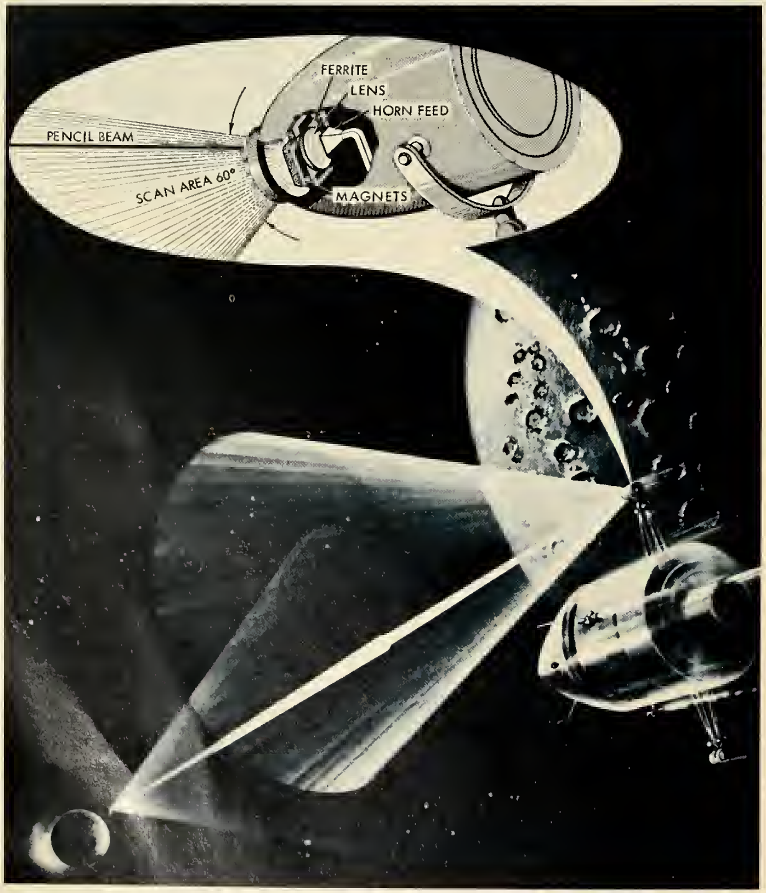
SPACE COMMUNICATIONS are expected to increasingly exploit millimeter waves, digital communications links tied into monitoring ground terminals, and adaptive antennas. A major development will be direct broadcasts, particularly telecasts, into home receivers.

The drive for millimeter-wave transmissions stems from 1) the tremendous span of bandwidths opened up, 2) the military and business security offered, and 3) the relatively small and lightweight components required.

Digital communications, in particular, lend themselves to link privacy and additionally to forward error detection and correction coding techniques.

Adaptive antennas, especially large ones mounted on comsats, are expected to ease considerably the cost and complexity of ground receiving equipment and make direct satellite-home broadcasts economically feasible.

With an 18-in. millimeter antenna under development for the Air Force by Sylvania, bulk data flows when electronically swept beam hits target.



"Stationary" satellites urged—The synchronous satellite is basic to an economic and effective system of worldwide communications for the 1970's and beyond. This point was stressed by a number of communications specialists.

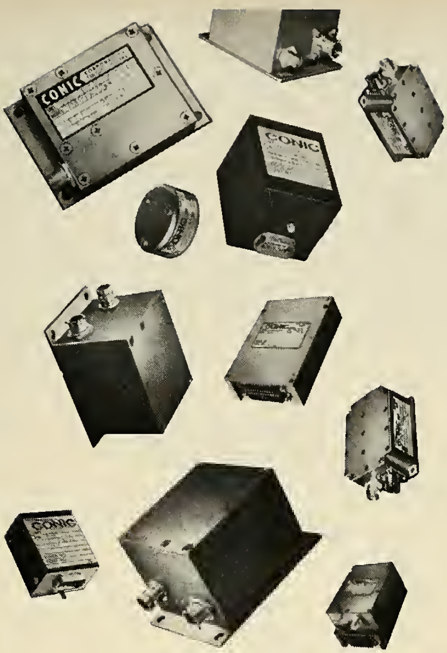
George S. Shaw, senior vice president and founder of Radiation, Inc., Melbourne, Fla., suggests using a beamwidth of six degrees to cover the geographic areas of most interest to broadcasters. This satellite system would show a gain of 30 db over an isotropic source and a transmission advantage of 10:1 over a satellite system attempting near-hemispheric coverage.

Direct telecast to home receivers is not expected to be delayed by any severe technical bottlenecks except shortage of satellite power. Shaw decried the shortsightedness of government agencies in their "on-off behavior" in developing space nuclear power supplies for communications systems. The 30-kw to 50-kw power supply will be "desperately needed," he said.

In a study of the technical needs for direct telecasts to the home, Shaw hypothesized a 10-kw transmitter—about ⅒ the size of the usual Earth-bound TV transmitter—broadcasting 900 mc through a 15-ft.-dia. antenna with six-degree beamwidth. The geographic coverage would be seven million square miles and include a population of 200 million to one billion. The transmitter would provide a 70-db signal and require a 1-ft.-dia. receiving antenna with 7-db gain. Calculated output signal-to-noise ratio would be 30 db. The system would need a solid-state, state-of-the-art preamplifier in the home set, according to Shaw.

For hemisphere telecasts at 216 mc and 10 mw of transmitting power, Shaw says a dipole or "in-the-set" antenna would be sufficient for an output signal-to-noise ratio of 30 db, granted a receiver sensitivity of 107 db.

The radio-telephone market is growing at the rate of 15% a year, according-



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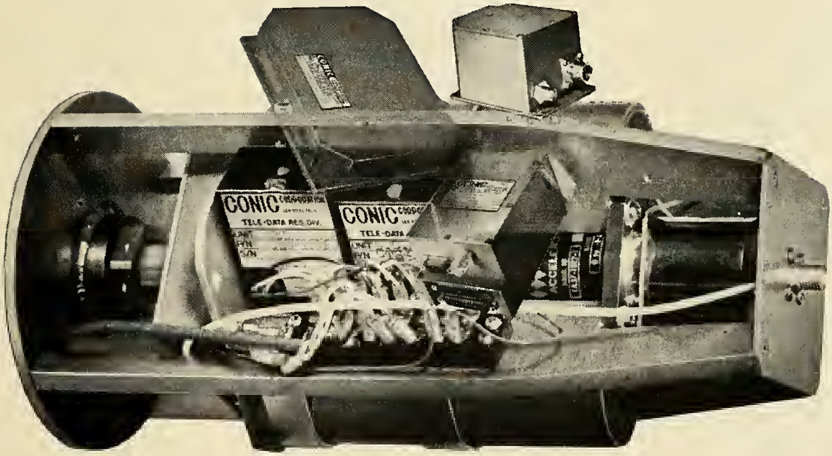

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ing to Shaw, "and we think it will go into space in about 15 years from now." Use would be for aircraft, ships, buses, business and education. A satellite with a minimum of one-watt/voice channel would be effective in a satellite with several hundred watts capacity. Communications could be established in the microwave band with an aircraft topped by a 24-in. antenna. Single sideband operation and no artificial interference is assumed. "We would much prefer going to 10 watts/voice channel," said Shaw, although the lower power system would work.

With a satellite using a number of individually operable beams, a hemisphere might be covered without necessarily sacrificing the gain of narrow beamwidths. Only one beam might be turned on at a time, or each might operate simultaneously with different customers. In the latter case, the results would be roughly equivalent to a single 18-degree hemispheric beam and the only advantage would be in flexibility.

Digital communications—Satellite communications systems will be increasingly tailored to provide digital communications links. This will stem from a need for link privacy, effective satellite multiple access, and the use of efficient modulation methods, said James Rahilly, senior engineering specialist at Philco Western Development Labs.

He believes that forward error detection and correction coding techniques will find increased application for digital data transmission. These methods will be used to correct random errors when thc communications system does not use a reverse communications link control path.

Both the terminal and the communications satellite will go predominantly solid-state. Emphasis will be on increasing logic speed and integrating the packaging of multi-function components. In some of these systems, a conversion in modulation methods between the up-link and down-link may also occur in addition to signal regeneration, according to Rahilly.

Eventually, he says, computer control will not only be felt in the ground telecommunications network, with which the comsat terminal will interface, but also in the comsat terminal itself. By using either small, programmed station controllers within the terminal or computers remote from the terminal and tied to it by means of land lines, it will be possible to achieve fully automatic, unattended comsat terminal operation.

By these means, terminals may have all their subsystems and functions open to high-speed monitoring. When a departure from desired operating performance or a complete failure is observed by the computer monitor, diagnostic analysis can rapidly be made to isolate the problem and determine the remedy.

By using switchable, redundant components, the computer may through diagnostic analysis give commands to switch out failed components and replace them with standbys. Because of the microsecond speed of computer operation, an interruption in service, in the case of many types of failures, might not even be observed by the users.

In addition to "diagnosis and cure" attributes, the terminal may also communicate its status to a remote tactical or strategic switching center for supervisory monitoring.

If store and forward message traffic is handled, the computer facility would help control it. The facility would examine the blocks of data received to see if there are data errors, and would provide automatic repeat requests in the reverse path if needed.

For forward error detecting and correcting operations, the required logic and data storage operations can become considerably more complex; generally, the computer system will only interfere with the link traffic when it is unable to properly carry out responsibility for correcting the detectable er-

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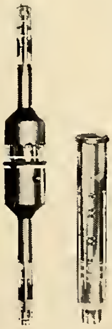

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A dual gun storage tube capable of simultaneous reading and writing. Over-all construction permits extremely accurate alignment of both guns.

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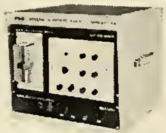
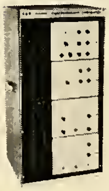
Slow scan television systems
Scan conversion systems
Special purpose test equipment



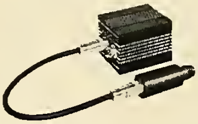
ED 6025

Slide Video Generator
Completely transistorized, the 6025 is designed to provide video signals by scanning 35 mm slides. Various scanning formats can be obtained by selecting the appropriate plug-in module.



ED 6021

Universal Scan Converter
This completely solid state system is capable of converting between various scan formats. Typical conversions include: PPI to TV, slow scan to TV, character writing input to TV output simply by selecting proper module. The system can be modified to any specific customer requirement. It is designed around the TD 1372 dual gun tube.



ED 6038

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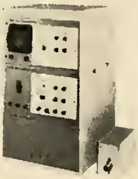

ED 6030

Slow Scan TV System
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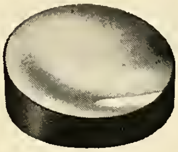

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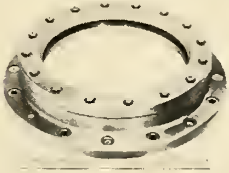

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rors. Either block coding or convolutional coding will be used for the forward error detection and correction process.

At the transmitter point of the satellite communications link, every effort will be made to reduce the level of useless redundancy in the data to be sent. The approach to achieving a desired level of data compression will depend on whether the traffic handled is alpha-numeric, pictorial or digitized voice, and on the recognition quality desired by the user.

Millimeter frequencies—Millimeter wave frequencies (30 to 1,000 gc) offer a promising area for future space communication links. This new region of the spectrum provides a relatively untouched and unlimited band of frequencies that offers many advantages: wide bandwidth capabilities, reduced signal density, communication security, high-gain/small-aperture antenna characteristics, reduced component size and weight, and superior background noise characteristics. The 30- to 100-gc band alone, for example, provides more than twice as much spectrum space than has been available for all uses since the beginning of radio. This untapped and largely unexplored region of the spectrum offers a vast range of possible applications for future space systems.

For example, communications between a high-flying aircraft and a satellite can be made jam-free and secure from ground-based facilities because of the high antenna directivity, large bandwidth, and high attenuation of millimeter waves in the lower atmosphere, says T. M. Johnston, RCA Defense Electronic Products manager, systems analysis.

Major organizations engaged in millimeter systems research include Airborne Instruments Laboratory of Cutler-Hammer, Inc.; Bell Telephone Labs., Inc.; General Motors Corp. (Santa Barbara); Martin Co.; North American Aviation, Inc.; Raytheon Co.; Sylvania, and TRG, Inc. Universities involved include Georgia Institute of Technology, Johns Hopkins (Carlyle Barton Lab.), Ohio State, Stanford, Colorado and Illinois. The three military services, the space agency and the National Bureau of Standards are all sponsoring millimeter work.

Theoretical studies indicate that the millimeter region may potentially offer the best frequency range for spacecraft-to-spacecraft communications on the basis of noise distribution. Lower-frequency radio waves are limited in space applications because of the interference caused by cosmic noise. On the other hand, although lasers are not so affected, it appears that quantization noise may limit their message-carrying capability in deep-space probes. The millimeter-submillimeter band, which lies between those two extremes at what may prove to be the lowest cumulative noise region of the spectrum, seems to offer a potentially useful compromise.

These noise characteristics are assuredly persuasive for using millimeters for space communications and even, at some frequencies, for Earth-space links. There is little evidence of any strong cosmic noise at millimeter wavelengths; atmospheric noise is also moderate in the low-absorption "window" regions. In order to specifically determine these windows, researchers J. C. Wiltse and J. W. Dees at Martin-Orlando's Electromagnetic Research Lab. are making absolute absorption measurements across the millimeter band. They also are studying attenuation characteristics of other planetary atmospheres as a possible prelude to further space exploration. Some of this work is under NASA sponsorship.

Experiments needed—Problems caused by the atmosphere—such as absorption, refraction, and dispersion—result in fading, multipath and sky noise effects. Although much data can be obtained from ground measurements, a satellite-to-ground experiment must be performed to obtain the data necessary to characterize future Earth-space millimeter wave links, affirm Martin-Orlando researchers. Aircraft-to-ground experiments would also yield useful data and would particularly aid in evaluating, testing, and proving the millimeter equipment prior to satellite experimentation. As a first step toward solution of millimeter systems problems, researchers at Martin-Orlando have designed a number of experiments aimed at establishing design parameters for satellite-ground and satellite-satellite links. Calculations for orbital altitudes from 100 up to 20,000 n. mi. have been made to determine antenna gains and beamwidths, transmitter power requirements, Doppler shifts, and effects of atmospheric attenuation near 35 and 94 gc. These two frequency bands represent the only two useful windows below 100 gc in the millimeter range.

A survey of existing antenna facilities available for millimeter experiments has disclosed several with the necessary capabilities. A typical example is Aerospace Corp.'s 15-ft.-dish antenna with associated tracking and computing equipment at El Segundo, Calif. Considerable work has gone into determination of satellite data time relative to different orbital altitudes and ground antenna elevation angles. Antenna characteristics—satellite stability, gain, beamwidths, pointing accuracy—have been considered and parameters established.

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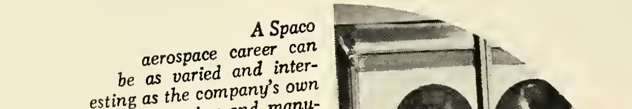

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Transmitter power requirements, satellite instrumentation, receivers, bandwidth, and number and spacings of channels have also been calculated.

These preliminary studies have shown the feasibility of millimeter-wave experimental Earth-space propagation/communications links within reasonable limits of power, weight, and space allocations in a satellite. Simple single-channel systems of modest bandwidths can be used up to 100 gc even in small satellites. Multi-channel or wide-band systems are feasible for larger satellites in this frequency region. Equipment availability is a problem only above 40 gc. However, space qualification of millimeter wave hardware is still a problem, even below 40 gc.

Unfortunately, few off-the-shelf components have been available and little operational ground equipment is available above 40 gc.

Power sources are a case in point. Electron beam devices are limited in power output due to the extremely small size of cavities and the problem of heat dissipation. For example, klystron tubes have lower efficiencies at millimeter wavelengths. In fact, none are available above 170 gc. At frequencies above 200 gc, there seems to be little hope of building conventional beam devices which would be useful in spacecraft instrumentation.

Optical mixing—A possible means of obtaining higher power sources is optical mixing. For example, mixing of the output of pulsed crystal or gas lasers, although presently inefficient, would yield a difference frequency in the millimeter or submillimeter wave region. The power output would be greater than the microwatts now obtainable from harmonic generation techniques. Further, certain dopings of crystals are expected to enable mixing of two lines emitted from a single crystal laser. This would be an advantage since it would eliminate problems involved in the simultaneous firing and mixing of two separate lasers and would result in increased power. Where stable sources are required, phase-locking techniques can be used.

Detectors pose another problem. However, since adequate detectors are available in both the microwave and optical regions, these can possibly be extended in both directions to provide suitable components in the millimeter region. Cryogenic detectors, which provide adequate sensitivity at millimeter frequencies, furnish one possible solution, but the required cooling is a problem. Superheterodyne techniques can also be used to detect even lower power levels. Superheterodyning has been used to detect signals up to 650 gc and, although this type of receiver

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is practical for millimeter use, a search for better materials in which mixing can occur is still proceeding.

Superheterodyne receivers mainly employ point-contact crystal diodes, still the most widely used millimeter wave detector. The point-contact superheterodyne is apparently unsurpassed in the millimeter region, with reported sensitivities of 10^{-15} watt at 1 cps bandwidth and response times of 10^{-9} second. Furthermore, this type of detector does not require cooling, a real advantage for spaceborne applications.

In the design of transmission devices, the millimeter engineer has borrowed from both the optical and the microwave region. In the optical area, geometrical optics—lenses, mirrors and prisms—can be used to transmit, focus, reflect, and refract the electromagnetic waves. Such components, however, are large with respect to wavelength. On the microwave side, conventional waveguide components—such as horns, transmission lines, couplers, phase shifters—which are comparable in size to the wavelength are available. Therefore, a combination of the two techniques—"quasi-optics"—is used. As an example, a waveguide horn may be used in conjunction with a lens to transmit energy in the millimeter region.

However, it is clear that only conventional waveguide components will be used below 100 gc.

Sub-synchronous satellites—A satellite communications system that can exploit laser and millimeter frequencies to obtain global coverage has been invented by W. H. Grisham. This is the "Rosae" system (patent pending), which makes use of a balanced array of 12 satellites, moving in three orthogonal planes. In each plane, two satellite pairs rotate in opposite directions to facilitate use of rf beam pairs, which also move in opposition aboard the satellites. Coverage of 100% of the globe, with an over-coverage of 3:1, is forecast.

According to Grisham, many advantages derive from making long hops over a satellite-to-satellite path rather than making many ground-satellite-ground hops. At millimeter frequencies, the space links can use huge bands of frequencies (such as 57 to 66 gc), virtually isolated from ground interference, and small but high-gain antennas. Since the signal traverses the atmosphere only when entering and leaving the net, phase uncertainties are minimized and costly ground repeaters are eliminated, says Grisham. Handover is considered to be eased since rising satellites replace setting satellites within the ground station's beam and with an equal but opposite Doppler offset.

With the Rosae system, satellites can use mechanically rotated apertures as well as cylindrical phased arrays to "spin" the narrow beams (at five revs/day) to follow the receiving satellites without attitude disturbances from unwanted torques. Gyroscopic torques and those induced by angular velocity changes are canceled out by the opposite moving antenna mounts, which make the system compatible with reliable but delicate gravity-gradient stabilization.

By using orbits synchronized to five times the Earth's spin rate, the satellites can be piggy-backed, yet initial injections and subsequent replacements can use efficient trajectories without restrictive launch window tolerances, according to Grisham. Therefore, only six boosters are needed. The station-keeping needed is a function primarily of the beam widths used and may not be needed if initial injection corrections are sufficiently accurate.

Large-aperture antennas—NASA's experiments with large communications antennas in space will start with the flight of *Applications Technology Satellite 4,* expected to have a parabolic dish 30 ft. in diameter or larger. Aim is to be able to operate over a wide band of frequencies, extending up to 10 gc. The definition phase for this satellite is expected to start early in FY 1967, with development starting later that year. Launch vehicles under consideration are the *Atlas-Agena, Atlas-Centaur,* and *Titan III-C.*

A large orbiting antenna that would be equivalent to an orbiting Deep Space Instrumentation Facility is being studied by Space-General Corp. under contract from the Ames Mission Analysis Div. of NASA's Office of Advanced Research and Technology (OART). Aim of the 11-month study is to assess the feasibility of the concept and to examine applications for situations where multiple unmanned missions are under way or for continuous monitoring of manned interplanetary missions.

The use of a large orbiting antenna around Mars as a long-life relay station capable of transmitting up to 40,000 bits per sec has been proposed by TRW Systems Group. Douglas Aircraft Co.'s Missiles and Space Systems Div. has suggested that a Sun-orbiting communications satellite may be needed to eliminate the 60-day blackout in communications from a manned interplanetary probe as it passes behind the Sun.

Astro Research Corp. is studying the structural problems of large orbiting apertures suitable for low-frequency radio astronomy under a $90,000 contract from OART. These could have communications applications in the 1980's.

The firm is primarily concerned with

spinning filamentary structures that will provide discriminations of three degrees of arc at 4 mc and is looking at a wide range of configurations, including dipole arrays, parabolas and interferometers. At this frequency, the aperture involved may be between 1,500 and 5,000 ft. Astro has previously studied a spinning parabola of 1,500-meter diameter made of lightweight filamentary materials and concluded that in a 500-mi. orbit, gravity-gradient loads would be no problem.

Fuel requirements for stabilizing very large apertures in orbit have been studied by R. H. Frick at Rand Corp. One technique for measuring the attitude of the satellite from the ground would be to make use of two crossed interferometers mounted in the plane of the reflector. Frick found that with the peripheral thrusters, the fuel to keep either a steady-state deflection or damp out low-frequency oscillations (orbital period) are of the same order as the fuel requirement for stationkeeping. However, if high-frequency oscillations in pitch and roll are present (100 cycles per day), then the fuel requirement becomes excessive.

Adaptive antennas—Henry Blanchard of Stanford Research Institute suggests that retrodirective arrays and other adaptive antennas of large size will allow various communications through a satellite to be directed in separate narrow beams to their appropriate receiving stations. This should greatly reduce the size of ground equipment for small users.

Continuing, he suggested that adaptive antennas using a large number of elemental radiators, each with its own transmitter-amplifier, could accelerate the use of all-solid-state satellites. Long-term reliability would be increased, with very little redundancy, since the loss of a few elemental circuits would not greatly degrade the overall system.

The Air Force Research & Technology Div. at Bolling AFB, Washington, D.C.—working along the lines Blanchard is suggesting—is investigating an orbital communication relay station. It would provide antenna gains achievable with phased arrays, free from stabilization requirements. Researchers expect the gain at the space vehicle to enable aircraft and mobile stations eventually to use such an orbiting relay.

This gain is achieved by covering the entire surface of the orbiting body with radiating elements. These are correctly phased and properly gated by the interrogating signals from the terminal stations. By using crossed dipoles or slots, designers have nearly the entire surface of the satellite.

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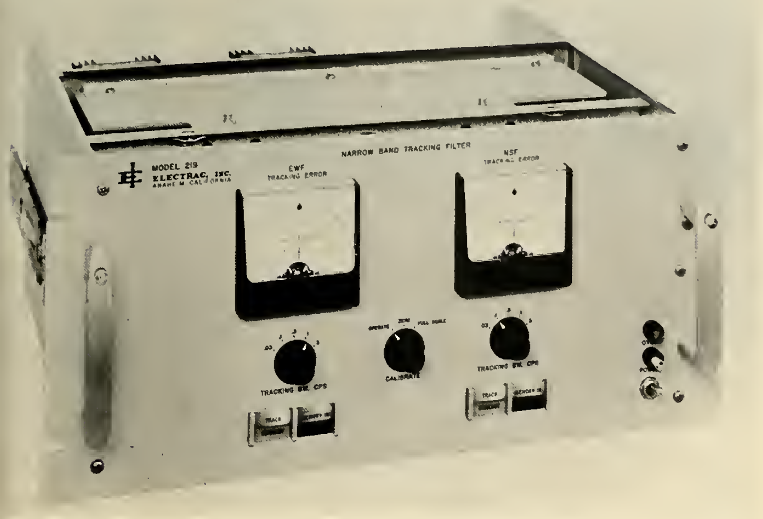

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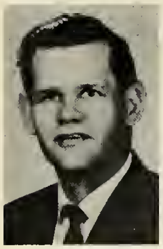
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Werner Koester: Named vice president and general manager of Oak Electro/Netics Corp., Ltd., subsidiary of Oak Electro/Netics Corp. He has been general manager of Oak Hong Kong since June, 1964.

Harlan M. Twible: Appointed vice president of marketing of the Bristol Co., a division of American Chain & Cable Co., Inc. He was vice president, marketing, of the Hays Corp.

Dr. George G. Chapin: Appointed director of the systems analysis laboratory for Litton Industries' Data Systems Div. He has authored a number of papers on the development of naval tactical data systems and automatic track processing.

Edwin H. Meier: Appointed a vice president of Hughes Aircraft Co.'s aerospace group. He is manager of the research and development division of the aerospace group.

Jack C. Handley: Elected a vice president of Electro-Optical Systems, Inc., a subsidiary of Xerox Corp., and named corporate director of finance and control.

William F. Eicher: Appointed vice president of operations of Hughes Aircraft Co. He was formerly manager of the Aeronautical Systems Div.

Donald W. Dressel: Appointed divisional vice president and manager of Memcor's Courter Div. He will be responsible for all phases of engineering, research, manufacturing and sales.

Robert B. Wolf: Appointed vice president of Itek Business Products. He will supervise the development, production and marketing of the company's line of commercial production equipment and supplies.

V. Reed Manning: Appointed associate head of the MITRE Corp.'s communications planning and research department.

J. L. Thorne: Appointed to the board of directors of Hawker Siddeley Aviation Ltd. He will serve as director and general manager of the company's manufacturing and development facilities at Hatfield, England.

Robert H. Beisswenger: Elected president of the Jerrold Corp. He joined the company in 1961 as general manager of its electronics corporation subsidiary.

Akio Morita: Elected chairman of the board of directors of Sony Corp. of America. **Ernest B. Schwarzenbach** has been elected to succeed him as president and chief executive officer.

John A. McCone: Elected to the board of directors of International Telephone and Telegraph Corp. He was formerly director of the Central Intelligence Agency.

Raymond R. Bourret: Named vice president of manufacturing of Pacific Plantronics, Inc. He is general chairman of "Workshops for Electronic Management," sponsored semi-annually by the Western Electronic Manufacturers Assn.

Conde Hamlin: Appointed executive assistant to the president of Emerson Electric Co. He will be responsible for special executive assignments for the company president, chairman of the board and chief officer.

Leo W. Killen: Named vice president of Autonetics' Strike Avionic Systems Div. He will direct planning, development and coordination of new military avionic systems.

Bruce A. Reese: Appointed director of the Purdue University Jet Propulsion Center, succeeding **Prof. Maurice J. Zucrow,** who has announced his retirement.

Clarence H. Linder: Elected president of Engineers Joint Council for 1966. He is an engineering consultant, charter member of the National Academy of Engineering and past president of IEEE.

George E. Spaulding, Jr.: Appointed senior vice president, responsible for the three industrially oriented divisions of Consolidated Electrodynamics Corp., a subsidiary of Bell & Howell Co.

Raymond L. Bisplinghoff: Elected president of the American Institute of Aeronautics and Astronautics. He advises NASA Administrator James Webb, on technical progress in such areas as supersonic transport development and the NASA Electronics Research Center in Boston.

Dr. John A. Wheeler: Elected president of the American Physical Society. He is professor of physics at Princeton University and has made important contributions in nuclear fission and controlled nuclear fusion.

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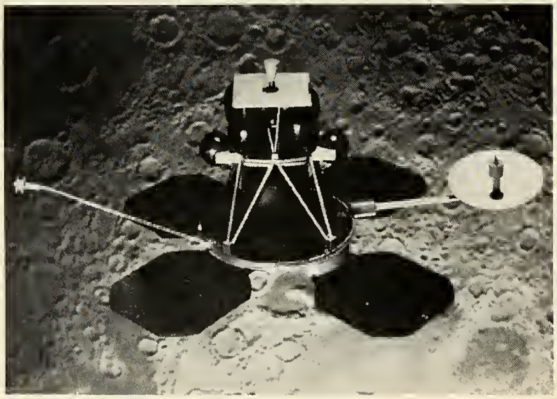

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A Big, Risky Budget

TO CHARACTERIZE as sparse a national budget which calls for fiscal-year expenditures of $30.039 billion with this industry is perhaps a misuse of the word.

But it is not wrong to say that this is a limited budget in several important areas.

It is important to analyze the Administration's Fiscal 1967 budget not in terms of what it may accomplish but in reference to what it may not accomplish.

"A budget is not simply a schedule of financial accounts," as President Johnson told Congress. "It is a program for action." It is imperative therefore to take a close look at the budget to see where that action is—and where it isn't.

Analysis of the FY '67 budget is not a simple matter. It has been cleverly mixed with a large FY '66 supplemental to such an extent as to conceal the massive increase in spending which it contains—as much for social and economic programs of the Great Society as for the Vietnamese war. The Administration has employed emphasis on the Southeast Asian conflict to take the heat off the fact that the nation now must begin to pay for the large social programs it has enacted. By dumping large funding requests for FY '67 defense spending into the FY '66 supplemental, it has eased the pressure on new obligational authority needed to finance Great Society projects.

Of some $14 billion requested in FY '66 supplemental funds for Vietnam, only $4.6 billion will be spent before the end of the current fiscal year. A good example of what this does to budget figures can be found in those for DOD procurement: over $7 billion is asked in new obligational authority for FY '66 but only $695 million of that will actually be spent in FY '66.

This fiscal legerdemain makes it possible to show an NOA increase of only $3.5 billion for DOD procurement. Assignment of some $6.3 billion of NOA funds to their proper places in the FY '67 budget would have jumped that increase to nearly $10 billion.

From an industry viewpoint, perhaps all of this juggling would be just of passing interest if it served only its partisan political purposes. But it also confuses analysis of exactly what is happening in defense spending.

The situation was not helped by a Defense Dept. briefing on the budget which was so void of worthwhile information as to be almost valueless. DOD has not, in the past, trumpeted its cutbacks but it usually has been reasonably frank about them. Such was not the case this year. Questions about programs on which funding has been reduced were so curtly cut off that it amounted almost to concealment.

These reductions are worthy of close examination, despite Administration protests that escalating Vietnam costs have not resulted in a cutback in any vital military programs.

TAKE FIRST THE CASE of the *Manned Orbiting Laboratory*. A year ago, we were assured enthusiastically that *MOL* finally was getting under way as a major Air Force project, one which had been determined to be important to the nation's welfare and which would receive substantial funding. Now, a high defense official cautions us of the technical difficulties inherent in *MOL* and advises "prudence" in proceeding with it. *MOL* funding therefore will not go up as planned but will remain at the same level. The fact is that *MOL* is so far within the state of the art that by next year the state of the art may be out of sight and *MOL,* as designed, will be as obsolescent as *Dyna-Soar*.

The decision against *Nike-X* production in FY '67, together with procurement of *Minuteman III* and additional *Poseidon* fleet ballistic missiles, has some interesting implications. Principal new feature of these two weapons is multiple warheads. That suggests Secretary of Defense McNamara may find the damage-limiting strategy of additional striking power more economically attractive at this time than an expensive anti-ballistic missile system. The desirability of additional warheads and penetration aids may also indicate Administration knowledge that the Soviets are pressing ahead with an ABM system, although the U.S. is not. Whatever the reason, there can be little doubt that reversal of what appeared to be a favorable situation for *Nike-X* resulted from economic pressures within the budget.

Officials of the National Aeronautics and Space Administration admitted that the *Apollo* budget now is so spartan that any major setback will clearly increase the risk of falling behind the lunar landing schedule. The program is without contingency funds. One high NASA official stated that if the manned spaceflight budget were $200 million lower, it would not be possible to achieve the lunar landing in this decade. That is shaving it desperately close.

An overall look at what the Soviets gain from this budget as a result of U.S. involvement in Vietnam reveals this:

- The *MOL* program, vital to U.S. space defense, is stretched out.
- *Nike-X* is stalled for at least another year.
- The *Apollo* manned lunar landing program, on which we have staked national prestige in a race with the Soviet Union, is endangered.

Little wonder then that the Russians have shown so little interest in helping to arrange a Vietnam peace settlement. The Administration effort to finance both a war and a Great Society without a taxation increase may prove extremely costly to the nation's future. Despite its record size, this is a risky budget.

William J. Coughlin

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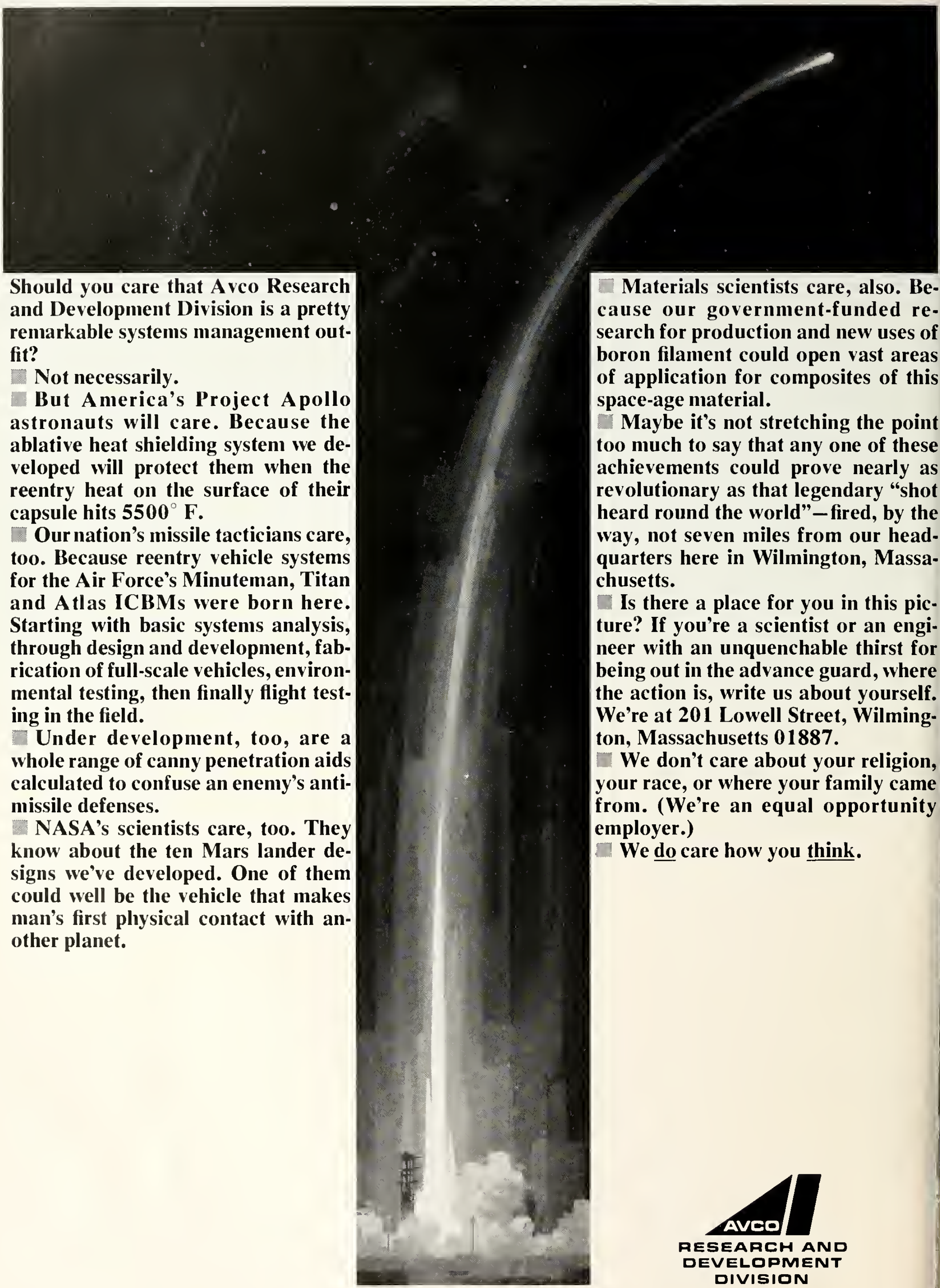

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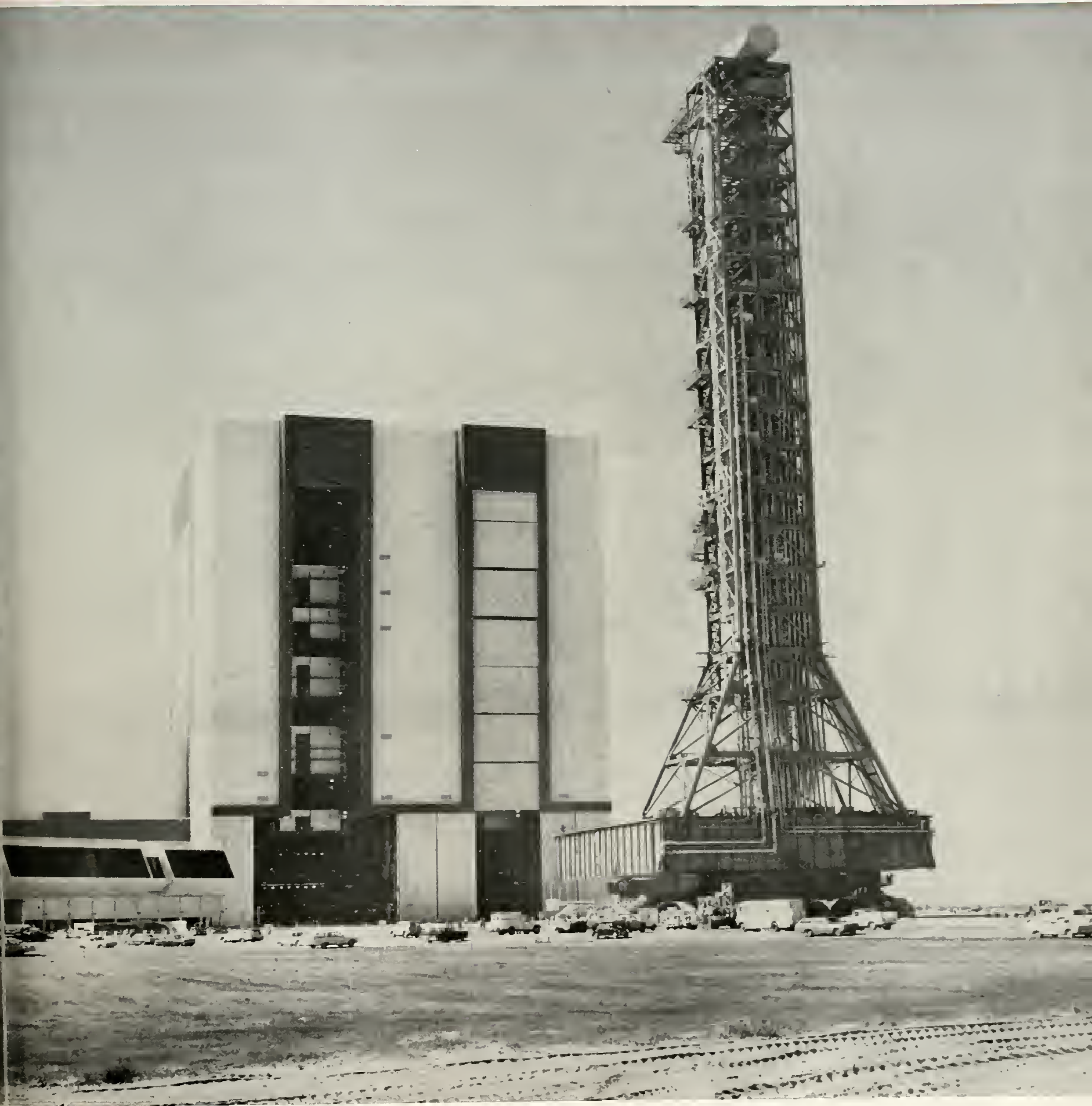

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Details of NASA Budget—Part I

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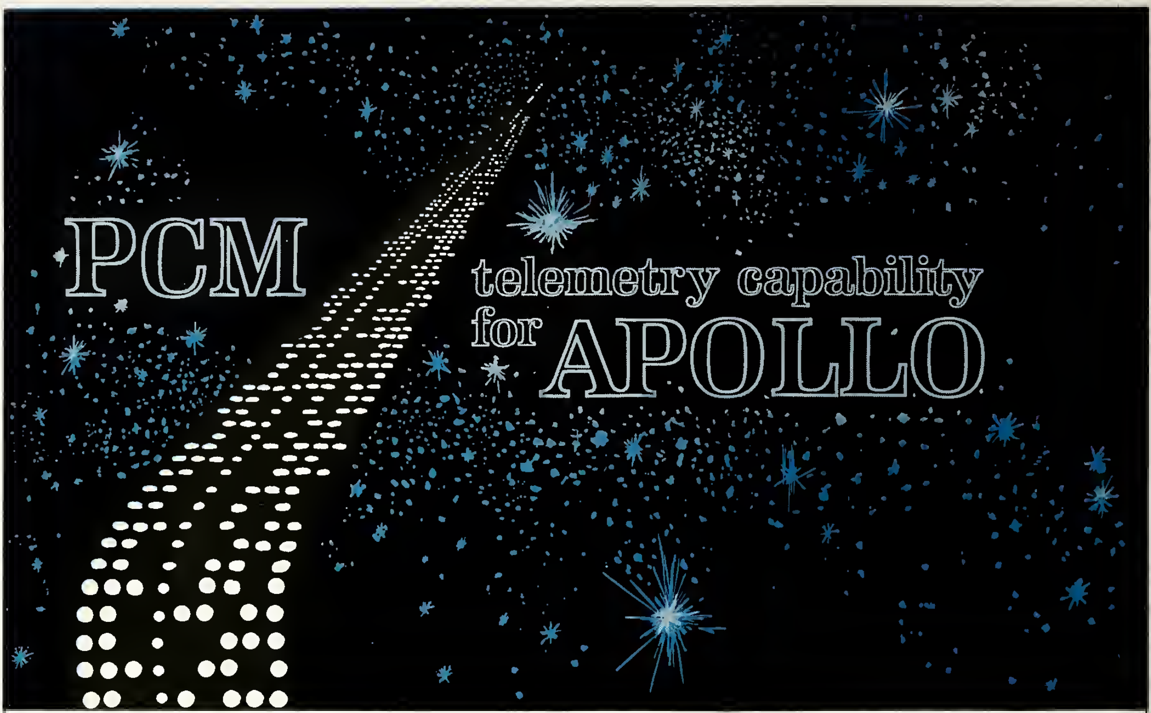

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Volume 18, Number 6 February 7, 1966

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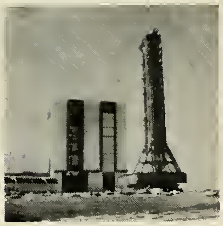
THE COVER



The crawler-transporter for the Saturn V launch vehicle moves toward Vehicle Assembly Building at Merritt Island Launch Area in Jan. 28 test. Crawler carried the Saturn V's launcher umbilical tower ¾ of a mile in nine-hour run on new bearing system. See story, p. 34.

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letters

View from Germany

To the Editor:

We in Germany are depressed by our lack of participation (in a space program) for reasons beyond our control and because our government is not interested—in view of our substantial earlier contributions.

I am intrigued by details like the investigation of Aerospace Corp. I am sufficiently detached to be amused by the discussion of differences between payment according to "need" or "worth of task."

Still, I am sufficiently familiar with the Russian mentality and that of their satellites to be disturbed by the thought of a corporation disrupted by such trifles. The Americans ought not, for the sake of a few million dollars, risk losing the advantages gained against the Russians during the last three years.

A German scientist
(name withheld on request)
Pforzheim, West Germany

Off by 1/204

To the Editor:

In the Jan. 17 M/R (p. 17), you stated that the *SA-204* is "planned as another unmanned orbital flight" and "the first manned orbital flight will be *SA-205*." This contradicts this *SA-204* long-duration *manned* orbital mission concept that I have.

Paul T. Lahti
Reliability Engineering
Apollo Support Dept.
General Electric Co.
Daytona Beach, Fla.

The reader's always write.—Ed.

Apollo Spacesuits

To the Editor:

I have been compiling a report for in-company use on *Apollo* pressure suit developments and performance characteristics. I have had to rely heavily upon data reported in MISSILES AND ROCKETS over the last year because your magazine has managed to provide excellent coverage of these developments.

I have incorporated selected photographs which appeared in past M/R issues in the report, namely the issues of Oct. 11, Nov. 15 and Nov. 22, 1965. The objective of the report is to assist product engineering, preliminary designers, and human factors personnel in understanding the configurations, capabilities, and limitations of the new equipment. The M/R illustrations are essential for this report, and I would greatly appreciate your cooperation in permitting me to reproduce them for company use.

John H. Duddy
Biotechnology Organization
Manned Space Programs
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Company
Sunnyvale, Calif.

Permission granted.—Ed.

Old Order Changeth

To the Editor:

The not-unusual complaint in R. B. Wallace's letter ("Star Sighting Problems," M/R, Jan. 24, p. 5) justifies not less than the best efforts by those rare individuals capable of creating basic concepts; and the letters by R. D. Kington, Jules Bergman and D. P. Green in the same column all point to a lack of integrity which is a negative catalyst detrimental to our country.

Another basic factor influencing our scientific and technological aspirations is the newly attained knowledge that casts doubt on the validity of established concepts. For example, the law of the conservation of mass and energy is not conclusive in view of momentum and entropy which are conserved only under certain conditions, and at persistence of waveforms wherein particles thereof are always changing and in which mass and energy disappear or come into existence. These phenomena are important in filtering out and storing anti-matter particles and in anti-gravitational devices.

Harry Bricker Fuchs
Farmingdale, N.Y.

The Downhill Path

To the Editor:

Your Jan. 10 editorial ("The Downhill Path") strongly censuring the Johnson Administration for its "brazen use of defense contracts to fight the price increases of the steel industry" eloquently presents some very valid points—and I note that it apparently has been well received by many of your readers.

However . . .

It seems to me that one could make an equally strong case that the Administration had a *clear duty* to move with utmost force and speed in whatever legal approach (no one has yet questioned the legality of the action taken) was available to prevent the inflationary reaction that certainly would have followed such a major boost in the price of steel.

The Federal Government has a duty to our great free enterprise system. Yes. It also has a duty to the entire nation to do its best to control inflation. I don't think history shows us that any other agency can be trusted with the job.

John Goodman
Detroit

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The Countdown

WASHINGTON

Surveyor Makes Deliberate Progress

Jet Propulsion Laboratory reports that the *Surveyor* soft-landing system underwent a second successful test at Holloman AFB, N.M., on Feb. 1—two days before the Soviet *Luna-9* successfully soft-landed on the Moon (see p. 9). Test involved a vehicle weighing 225 lbs. to simulate the lower lunar gravity. It was dropped from a balloon at 1,450 ft. and its terminal guidance system operated three liquid rockets to simulate a landing at an altitude of 500 ft., following which the craft was lowered to the ground by parachute. In forthcoming tests, the vehicle will be powered all the way to the ground.

House Space Group Calls Top Witnesses

The House Space Committee this week starts consideration of the FY 1967 NASA authorization and related matters. Space agency deputy administrator Dr. Robert C. Seamans is to testify on Monday, followed the next day by Gen. Bernard A. Schriever, chief of Air Force Systems Command, who will discuss the *Manned Orbiting Laboratory*. Associate administrator Dr. George Mueller will appear Wednesday, and will be followed by other top-level officials. Subcommittee hearings are due to begin the next week, with the Space Sciences and Applications group chaired by Rep. Joseph Karth (D-Minn.) meeting on Feb. 17.

Final DOD FY '66 Procurement Calculated

Total Dept. of Defense procurement for FY 1966 will reach $14.5 billion—when all the chips are down and if Congress allows the full procurement portion of the supplemental request it is now considering, Secretary McNamara told the House Armed Services Committee. Out of this total for the current fiscal year—including leftovers from other sources, the regular appropriation, the $1.7-billion amendment and the supplemental—will come these missile totals: Air Force, $1,242,800,000; Army, $368,000,000; Navy, $381,000,000; and Marines, $42,700,000.

NASA Ponders Ballistic Lifting-Body Flights

Space agency officials are currently weighing results of parallel six-month feasibility studies of ballistic suborbital flights of lifting-body vehicles. It's doubtful that the program will reach the systems definition stage in the near future. No funding was requested for it specifically in the FY '67 budget, and NASA also points out that other lifting body concepts—such as use of parachutes and propulsive lift—must be studied.

OSO, OGO Appetites Growing

Beyond the FY '67 request of $11.9 million for the *Orbiting Solar Observatory*, NASA estimates it will need another $24 million in FY '68 to complete the eight-launch program. Its *Orbiting Geophysical Observatory* has already cost $155 million; another $23.4 million has been requested for the next fiscal year and a further $27.3 million will be needed in FY '68 and later.

AEC Toughens Its Warheads

Improvements in hardening warheads against advanced enemy anti-ballistic missile countermeasures have been reported to Congress by the Atomic Energy Commission. In an unclassified report, AEC discloses that several possible designs have been identified and are being studied further with an eye to producing a system with hardness balanced against all possible threats. Some field tests have been made, and others are being scheduled.

INDUSTRY

Swan Song for NASA Big Solids?

Aerojet-General has scheduled the second ground test-firing of a half-length, 260-in-dia. solid rocket motor for Feb. 23 at its Dade Co. (Fla.) facility. This will be the last firing of a big-solid motor for NASA unless Congress approves more money for the program than the $3 million the space agency requested.

Martin Delivers LEM Tool Box . . .

A prototype tool box containing 16 geological tools for lunar surface sampling has been delivered by Martin-Baltimore to NASA's Manned Spacecraft Center in Houston for evaluation. Measuring 2 cu. ft., the box holds a battery-powered drill for chiseling or for coring holes up to 6 in. deep, a dust scoop, a hand-held magnifier, several types of survey instruments and range finders, and a retriever for picking up specimens too small to be grasped by a gloved astronaut. Also proposed is a scale to enable astronauts to stay within the 80-lb. limit on samples they can bring home from their mission.

. . . and Rodana Will Supply First Aid

Emergency medical kits containing drugs and first-aid supplies for *Apollo* spacecraft will be developed by Rodana Corp., Bethesda, Md., under a $70,000 Manned Spacecraft Center contract calling for delivery of a 4 x 4-in. mockup and six prototype models before July, followed by two "training" units prior to each *Apollo* mission. The kit is to be installed in a compartment 5 in. deep.

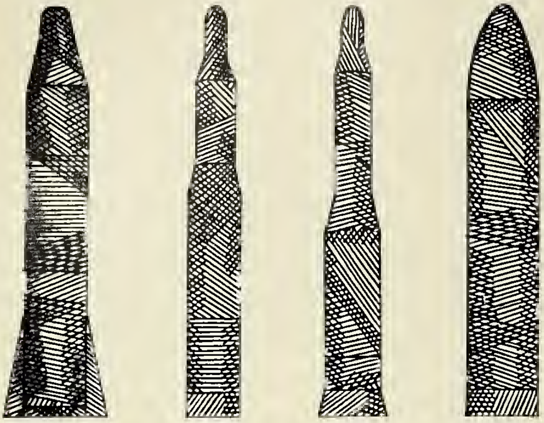
NOTS Adding Warhead R&D Plants

New warhead research and development facilities will be ready in June at the Naval Ordnance Test Station, China Lake, Calif. Two new facilities are being built at a cost of $327,575.

INTERNATIONAL

Japan May Orbit Spacecraft Next Month

A simple 40-lb. spacecraft may be orbited by Japanese scientists in late March as a prelude to the scheduled FY 1967 launch of a full-scale satellite (M/R, Dec. 20, p. 29). University of Tokyo scientists plan to fire a *Lambda 4S* rocket from their Kagoshima Space Center March 26 for what they call "overall tests" of systems for orbiting a satellite. It has been officially announced that the tests are part of preparations for the FY 1967 launch of "Japan's first satellite," but indications are that a probe will be orbited if all goes well in the tests. Another vehicle in the *Lambda* series—*4H*—is scheduled to be launched March 5 in a preliminary test flight.



HOW WILL POSEIDON DIFFER FROM ATLAS, TITAN, MINUTEMAN – AND POLARIS?

In many respects, like day and night. In its ability to penetrate enemy defenses. In its operational flexibility. And in other aspects which will make Poseidon an unequaled deterrent. But attaining these advances presents problems never before encountered in a ballistic missile program. The demand for new concepts is urgent. Engineers and scientists interested in contributing to a long-range program which is now in its early stages are invited to write or send resume to: K. R. Kiddoo, Professional Placement Manager, Sunnyvale, California. An equal opportunity employer.

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Soviet Lunar Probe Achieves Soft Landing

The Soviet Union—after five failures in previous attempts—has chalked up another space spectacular with the first successful soft landing of a spacecraft on the Moon and the first transmission of truly close-up pictures of the lunar surface.

The Russian *Luna-9* spacecraft, according to a Tass news agency announcement, touched down gently on the Moon at 1:45 p.m. EST Feb. 3 in the area of the "Ocean of Storms."

It gave the Soviet Union a major first in the race to land a man on the Moon, but U.S. officials denied the Russian claim that it put the Soviets in the lead in that race.

The U.S. will not attempt a soft landing until May of this year, putting the Soviet Union at least three months ahead in obtaining data on the composition of the surface. It is possible that the Soviet lead in this area may grow because the launch date for the first *Surveyor* may slip—and there is no certainty that the first U.S. attempt will succeed.

Officials point out, however, that new spacecraft and launch vehicles have to be developed to land a man on the Moon, and there is no indication the Russians have done this as yet. In addition, they note that this country has already accomplished space rendezvous—a necessary ingredient to a successful Moon landing—but the Soviet Union has not.

The transmission from *Luna-9* was first picked up by British scientists at the Jodrell Bank Observatory. Sir Bernard Lovell, director of the Observatory, hailed the feat as "bringing a Man's landing on the Moon entirely within the scope of this decade."

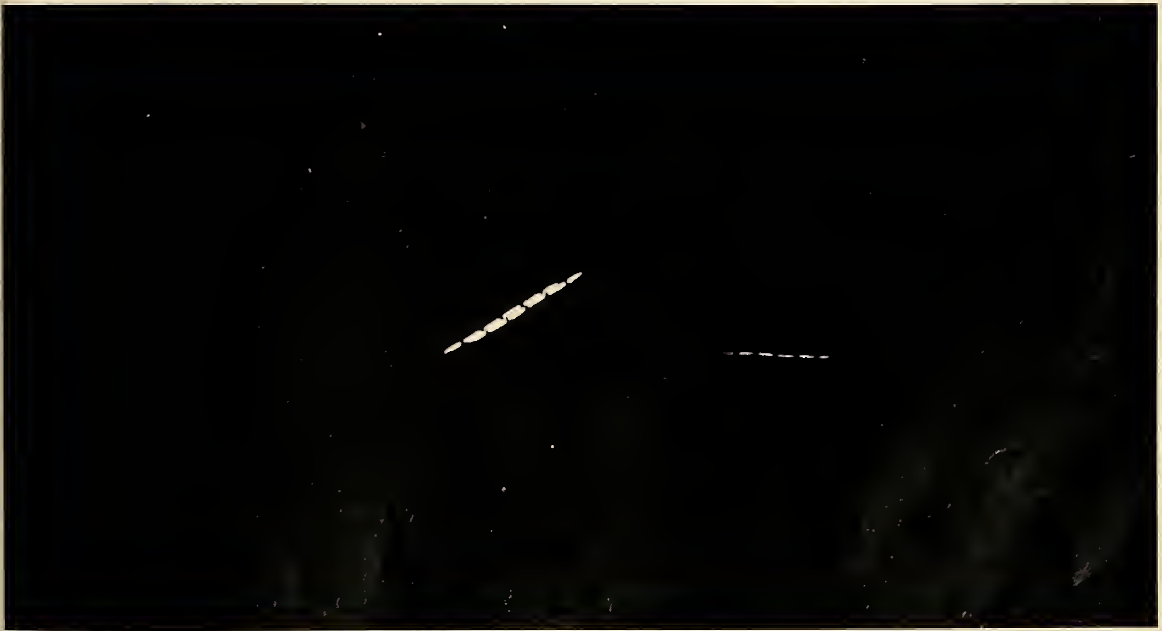
Dr. L. R. Shepard, director of the British Interplanetary Society, said the Russian achievement was far more difficult than the American space rendezvous of *Gemini 6* and *7* last December.

"It is marvelous," he said. "It is really a great achievement. I think it is a very great step forward—probably so far the outstanding event of the year."

President Johnson, in a telegram to Nicolai V. Podogorny, chairman of the Presidium of the Union of Soviet Socialist Republics, said, "Your ac-

Gemini 7/6 Rendezvous Photographed from Argentina

This unusual photo of the Gemini 7/6 rendezvous in space was taken at the Smithsonian Astrophysical Observatory's Villa Delores, Argentina, station at 00:54:45 UT (Greenwich Mean Time) last Dec. 16. A Baker-Nunn tracking camera was used with a 0.4-second exposure about 11 hours and 17 minutes after launch of Gemini 6. The two spacecraft had made their initial rendezvous and had separated again. Two faint dashes to right and below lines made by the two spacecraft are star trails. Distance between the spacecraft at time of exposure cannot be precisely measured but film evaluation indicates an angular separation of approximately 3 arc-minutes, or a minimum separation of at least ¼ mile.



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complishment is one that can benefit all mankind and all mankind applauds it. Your scientists have made a major contribution to man's knowledge of the Moon and Space."

Luna-9 was launched on Jan. 31 and after impacting on the Moon was transmitting back to Earth on a frequency of 188.538 mc.

Previous Russian attempts to soft-land on the Moon which failed included *Luna-5*, launched on May 9, 1965, which crash-landed; *Luna-6*, launched June 8, which missed the Moon completely; *Luna-7*, launched on Oct. 4, which landed at a speed only slightly higher than planned, but whose instruments were ruined by the impact; and *Luna-8*, launched on Dec. 7, which also failed during the final touchdown.

AAP/MOL Cooperation Studied

A NASA—DOD coordinating group, set up to handle NASA's *Apollo* Applications program and the Air Force's *Manned Orbiting Laboratory*, is working on identification of experiments for the two space programs and mutual use of facilities.

Dr. John S. Foster, director of Defense Research and Engineering, is co-chairman of the six-member manned space flight policy committee, along with NASA Deputy Administrator Dr. Robert Seamans. Other members are Dr. Dan Fink, director of strategic systems at DDR&E, Alexander Flax, assistant secretary of the Air Force for R&D, Dr. Homer E. Newell, NASA associate administrator for space science and applications, and Dr. George Mueller, NASA associate administrator for manned space flight.

In testimony before the House Military Operations subcommittee, Foster said that contract definition on the *Manned Orbiting Laboratory* is expected in May. One of the facilities which NASA may elect to use if it exceeds the unified S-band system, Foster told the committee, is DOD's Space Ground Link System. Development and installation of the system is expected to cost $32 million.

AEC Lets Joint Task Contract

The Atomic Energy Commission will negotiate with Aerojet-General Corp. and Allied Chemical Corp. for a contract for joint operation of test reactors and other facilities at the National Reactor Testing Station in Idaho.

Aerojet and Allied will form a new company, Idaho Nuclear Corp., to handle the work now being done by Phillips Petroleum Co. The company will take over the work on July 1 under a cost-plus-fixed-fee contract. Current level of work is about $29 million per year.

Phillips will continue R&D work for the AEC on reactor safety.

U.K. Joining in IDCSP

The Department of Defense and the British Ministry of Defense have signed a memorandum of understanding that provides for British participation in DOD's Initial Defense Communications Satellite Program (IDCSP).

Under terms of the agreement, signed by Defense Secretary Robert McNamara and U.K. Minister of Defense Denis Healey, Great Britain will provide several ground terminals for communications tests and experiments using the communications satellites.

The U.K. will pay for ground terminal construction and operation, but the U.S. will not charge for use of the comsats. The memorandum provides for an exchange of data obtained in the program.

Project offices for the program are the U.S. Defense Communications Agency and the U.K. Office of the Assistant Chief of Defense Staff (Signals).

Comsat To Go Synchronous

Communications Satellite Corp. is expected to announce its decision within the next two weeks to deploy a synchronous-orbit satellite system in 1967.

The corporation has reportedly chosen the synchronous configuration over a medium-altitude orbit system on the basis of the successful performance of the *Early Bird* satellite.

George P. Sampson, Comsat vice president for operations, said in a speech last week that his personal opinion was that "we will have a synchronous system for many years to come."

Shots of the Week

The Soviet Union successfully soft-landed the *Luna 9* spacecraft on the Moon Feb. 3 (see p. 9).

- NASA successfully launched the *ESSA I* satellite, the first of a new series of the Environmental Science Services Administration's operational weather satellites, from Cape Kennedy Feb. 3. The 305-lb. spacecraft, actually *Tiros XI*, was boosted by a *Delta* rocket into a slightly elliptical orbit. Parameters include a 522.6-statute-mi. apogee, 432.9-statute-mi. perigee and inclination of 81.1 degrees. Period is 100.2 min.
- A *Pershing* missile was successfully fired Jan. 31 by troops from the Federal Republic of Germany at the Hueco Range near Fort Bliss, Tex. The launch was part of their annual service practice exercise.
- A *Polaris A-3* missile was fired Jan. 31 from the USS Simon Bolivar, submerged off the coast of Florida.
- The Air Force fired a secret satellite from Vandenberg AFB, Calif., Feb. 2 using a *Thor-Agena* booster.
- NASA launched a 300-lb. instrument package Feb. 2 from White Sands Missile Range, N.M., to study the atmosphere of the star Alea Virginis.
- The Army successfully fired a *Lance* and a *Shillelagh* missile at White Sands Missile Range, N.M., Jan. 26.

More R&D Scrutiny Planned

The ranks of Congressional committees planning to investigate federal research and development programs this year is being joined by another, the Senate Committee on Government Operations.

In a move somewhat similar to the House Government Operations Committee, which has been looking at decision-making in R&D programs, the Senate committee describes its quest as being directed at the "origins" of these programs.

British Firm Wins HEOS Award

British Aircraft Corp.'s Guided Weapons Div. will design and manufacture elements for *HEOS (Highly Eccentric Orbit Satellite)* under a contract from Junkers Flugzeug Motorenwerke A.G.

The award, valued at about $750,000, will cover work on the attitude system and associated electronic equipment for the scientific satellite.

HEOS, being built by Junkers for the European Space Research Organization, will carry seven experiments developed by research institutes in Britain, Belgium, France, Italy and Germany.

Seamans Gets Senate Nod

The Senate Space Committee unanimously approved the appointment of Dr. Robert C. Seamans as NASA deputy administrator Jan. 28.

Seamans, formerly associate administrator for the space agency, succeeds the late Dr. Hugh L. Dryden.

collage

A random collection of fact, opinion and miscellany... some of it a blatant attempt to peddle the products and capabilities of Motorola's Military Electronics Division.

If this looks vaguely familiar it's because you've probably seen our humble little periodical that also bears the name, COLLAGE. In a bold effort to save a little time and a few bucks some genius in the Motorola hierarchy decided we ought to print a few of its less censorable items in high-class magazines like this.

At the forefront etc. Department

Our Chicago Center has developed a solid-state light deflector composed of alternate crystals of electro-optical materials and birefringent calcite. It is capable of both matrix and continuous character generation, and can distribute information onto photosensitive media or display screens. As of press time, no one is quite sure if we are selling these things or just bragging. If you get nasty though, we may send a recent *Engineering Bulletin* that tells about it. We're also pretty big on high-speed non-impact printers, but that's a story all in itself that we'll save for a later day.

For more information, write to our Chicago Center.

Continued on page 35

Circle No. 2 on Subscriber Service Card

NASA Details Plans for FY '67 Money

More than $1.2 billion is assigned to work on Apollo spacecraft; a detailed breakdown of allocations in manned and unmanned areas

by Hal Taylor

NASA's Manned Space Flight budget request for Fiscal Year 1967 reveals that $586.9 million will be needed for continued development of the *Apollo* spacecraft's Command and Service Module and $388.3 million for its Lunar Excursion Module.

Other major items in the spacecraft budget are $90 million for the guidance and navigation system, $38.9 million for integration, reliability and checkout and $96.5 million for mission support activities.

In the Space Science and Applications area, the space agency's total request of $90.4 million for the *Surveyor* program includes $82.4 million for the spacecraft, $4 million for experiments and $3.6 million for ground operations.

In addition, $50 million will be used to pay for the *Atlas-Centaur* launch vehicle which will boost the soft-landing spacecraft on its lunar-landing missions, bringing the total cost to $140.4 million.

The latter costs are included in a launch vehicle procurement program budget—for official budget purposes not considered part of the spacecraft program costs.

Prepared for Congress—The detailed figures on both the Manned Spaceflight and Space Science and Applications budget were revealed in a set of separate documents substantiating NASA's budget request which will be presented to the House and Senate Space committees this week. The breakdowns are shown in the tables on this page and page 13. A breakdown of the Office of Advanced Research and Technology's budget request will be included in the next issue of MISSILES AND ROCKETS.

BREAKDOWN OF NASA MANNED SPACEFLIGHT R&D BUDGET REQUEST

(millions of dollars)

GEMINI

PROGRAM	FY '66	FY '67
Spacecraft	107.2	19.1
Launch vehicles	88.6	8.5
Support	30.8	13.0
TOTAL	226.6	40.6

APOLLO SPACECRAFT

PROGRAM	FY '66	FY '67
Command and Service Modules	615.0	586.9
Lunar Excursion Module	310.8	388.3
Guidance and navigation	115.0	90.0
Integration, reliability, and checkout	34.4	38.9
Support	95.4	96.5
TOTAL	1,170.6	1,200.6

SATURN IB

PROGRAM	FY '66	FY '67
1st stage (S-I8)	63.4	56.2
2nd stage (S-IVB)	61.3	52.6
Vehicle instrument unit	40.7	36.0
Ground support equipment	24.1	7.4
H-1 engine procurement	9.2	4.0
J-2 engine procurement	14.0	7.7
Vehicle support	61.2	52.4
TOTAL	274.1	216.4

SATURN V

PROGRAM	FY '66	FY '67
1st stage (S-IC)	227.5	215.6
2nd stage (S-II)	255.8	257.7
3rd stage (S-IVB)	162.8	160.4
Vehicle instrument unit	72.5	73.6
Ground support equipment	104.5	73.8
F-1 engine procurement	67.4	85.8
J-2 engine procurement	74.7	75.2
Vehicle support	212.1	248.9
TOTAL	1,177.3	1,191.0

ENGINE DEVELOPMENT

PROGRAM	FY '66	FY '67
H-1 engine	6.4	5.5
RL-10 engine	1.9	—
F-1 engine	41.2	41.0
J-2 engine	41.7	37.9
Propellants and related engine support	42.7	26.6
TOTAL	134.0	111.0

APOLLO MISSION SUPPORT

PROGRAM	FY '66	FY '67
Operations	104.1	154.4
Systems engineering	26.0	26.0
Supporting development	32.2	32.8
Apollo Applications	48.0	41.9
TOTAL	210.3	255.2

ADVANCED MISSION STUDIES

PROGRAM	FY '66	FY '67
TOTAL	10.0	8.0

Look into future—The special budget material also contains this information on NASA's planning for future programs in both the manned and unmanned areas:

—The FY '67 budget requests funds for preliminary systems definition of a manned space station program, as well as preliminary systems definition of a ferry vehicle to transfer men and supplies to it.

—The space agency now feels that *Apollo* program technology will be sufficient to achieve a manned fly-by of Mars, but that new technology (i.e. new spacecraft and launch vehicles) will have to be developed before a manned landing on the planet is achieved.

—NASA now considers Jupiter its next goal in unmanned exploration of the planets following Venus and Mars.

—Its request for the *Apollo* Applications Program, totaling about $100 million, will be used to insure the continuity of production capability of the basic *Apollo* spacecraft. It will also pay for project definition of the AAP program and for development of some of its experimental payloads.

Module progress—In discussing its request for the *Apollo* spacecraft, NASA said that the Fiscal '67 request would mean that the first flight-rated Block II Command and Service Module could be delivered to Cape Kennedy for checkout and preparation for flight in the last half of the year.

In addition, 10 more Block II CSM's will be in the process of assembly, systems installation and checkout. The Block II configurations will be used in Earth-orbit rendezvous flights on the *Saturn IB* and for lunar mission simulation flights and *Saturn V* flights to the Moon.

The Lunar Excursion Module funding request will complete the major portion of the ground development and qualification test for such key systems

NASA SPACE SCIENCE & APPLICATIONS FY '67 R&D REQUEST

(in millions of dollars)

PHYSICS & ASTRONOMY SUPPORTING RESEARCH & TECHNOLOGY

	1966	1967
TOTAL	23.8	22.9

SOLAR OBSERVATORIES

	1966	1967
Orbiting Solar Observatory (OSO)		
Spacecraft	6.0	6.8
Experiments	3.6	5.1
Subtotal OSO	9.7	11.9
Advanced Orbiting Solar Observatory (AOSO)		
Spacecraft	10.4	—
Experiments	3.3	—
Ground operations	0.9	—
Subtotal AOSO	14.8	—
Total OSO and AOSO	24.5	11.9
Delta (launch vehicle procurement program)	(1.0)	(1.7)
TOTAL (including launch vehicles)	(25.5)	(13.6)

ASTRONOMICAL OBSERVATORIES

	1966	1967
Spacecraft and support	17.2	23.1
Experiments	7.3	6.1
Total spacecraft and support	24.6	29.2
Atlas-Agena (launch vehicle procurement program)	(16.7)	(9.0)
TOTAL (including launch vehicles)	(41.3)	(38.2)

GEOPHYSICAL OBSERVATORIES

	1966	1967
Spacecraft	16.9	14.5
Experiments	11.6	8.8
Total spacecraft and support	28.6	23.4
Thor-Agena (launch vehicle procurement program)	(3.7)	(3.5)
Atlas-Agena (launch vehicle procurement program)	(6.2)	(3.1)
TOTAL (including launch vehicles)	(38.6)	(30.1)

EXPLORERS

	1966	1967
Geophysical and interplanetary Explorers	13.1	12.3
Astronomy Explorers	5.0	9.1
Geodetic Explorers	3.2	1.6
Total Explorers	21.4	23.0
Scout (launch vehicle procurement program)	(6.3)	(3.8)
Delta (launch vehicle procurement program)	(4.8)	(11.6)
Thor-Agena (launch vehicle procurement program)	(6.7)	(2.9)
TOTAL (including launch vehicles)	(39.2)	(41.4)

SOUNDING ROCKETS

	1966	1967
Experiments	6.7	6.7
Rocket development	0.8	1.0
Attitude control systems	3.5	3.4
Engineering support	0.4	0.4
Test and evaluation	0.2	0.2
Ground instrumentation	3.0	3.2
Rocket procurement	3.7	3.9
TOTAL	18.5	19.0

LUNAR & PLANETARY SUPPORTING RESEARCH & TECHNOLOGY

	1966	1967
TOTAL (including launch vehicles)	38.6	40.1

SURVEYOR

	1966	1967
Spacecraft	105.4	82.8
Experiments	3.4	4.0
Ground operations	2.8	3.6
Total spacecraft and support	111.6	90.4
Atlas-Centaur (launch vehicle procurement program)	(50.0)	(50.0)
TOTAL (including launch vehicles)	(161.6)	(140.4)

LUNAR ORBITER

	1966	1967
Spacecraft	49.0	20.3
Experiments	0.1	2.3
Ground operations	3.2	2.0
Total spacecraft and support	52.4	24.6
Atlas-Agena (launch vehicle procurement program)	(17.0)	(4.5)
TOTAL (including launch vehicles)	(69.4)	(29.1)

MARINER

	1966	1967
Spacecraft	11.2	16.0
Experiments	3.4	4.0
Ground operations	3.3	6.1
Total spacecraft and support	18.0	26.1
Atlas-Agena (launch vehicle procurement program)	(2.5)	(7.2)
TOTAL (including launch vehicles)	(20.5)	(33.3)

VOYAGER

	1966	1967
Mission design	2.0	1.5
Spacecraft system	8.0	0.5
Capsule system	7.0	8.0
TOTAL	17.0	10.0

PIONEER

	1966	1967
Spacecraft	6.3	4.3
Experiments	5.2	1.5
Ground operations	1.2	0.9
Total spacecraft and support	12.7	6.7
Delta (launch vehicle procurement program)	(5.5)	(1.0)
TOTAL (including launch vehicles)	(18.2)	(7.7)

SUSTAINING UNIVERSITY PROGRAM

	1966	1967
TOTAL	46.0	41.0

LAUNCH VEHICLE SUPPORTING RESEARCH & TECHNOLOGY

	1966	1967
TOTAL	4.0	4.0

CENTAUR DEVELOPMENT

	1966	1967
Vehicle development	40.4	17.0
Supporting services	—	—
Instrumentation	—	—
Atlas boosters	—	—
RL-10-A3 engine improvements	10.0	12.0
Propellants	0.8	0.7
TOTAL	51.3	29.7

SCOUT PROCUREMENT

	1966	1967
Vehicles	3.6	3.6
Motors	1.9	2.5
Logistics and other	2.1	0.3
Sustaining engineering & maintenance	4.0	4.0
TOTAL	11.7	10.4

DELTA PROCUREMENT

	1966	1967
Delta stages	10.3	8.7
Thor boosters	9.1	9.0
Propellants	0.5	0.6
Third stages	0.8	0.4
Sustaining engineering & maintenance	7.0	4.0
TOTAL	27.9	22.9

AGENA PROCUREMENT

	1966	1967
Agena production	12.6	11.3
Agena mission modifications	31.0	14.6
Thor procurement	3.7	3.8
Atlas procurement	17.0	17.7
Propellants	0.5	1.1
Sustaining engineering & maintenance	6.0	6.0
TOTAL	71.1	54.7

CENTAUR PROCUREMENT

	1966	1967
Vehicle production	39.1	35.3
Atlas procurement	6.4	9.7
RL-10 engine procurement	3.2	3.1
Propellants	1.2	1.7
Sustaining engineering & maintenance	14.0	14.0
TOTAL	64.0	64.0

ATLAS PROCUREMENT

	1966	1967
Atlas vehicles	—	—
Sustaining engineering & maintenance	4.0	—
TOTAL	4.0	—

BIOSCIENCE SUPPORTING RESEARCH & TECHNOLOGY

	1966	1967
TOTAL	15.1	14.7

BIOSATELLITE

	1966	1967
Spacecraft	12.3	12.9
Experiments	8.6	7.1
Ground operations	0.6	0.7
Total spacecraft and operations	21.6	20.7
Thor-Delta (launch vehicle procurement program)	(9.5)	(4.5)
TOTAL (including launch vehicles)	(31.1)	(25.2)

METEOROLOGICAL SUPPORTING RESEARCH & TECHNOLOGY

	1966	1967
TOTAL	8.3	9.1

TIROS/TOS IMPROVEMENTS

	1966	1967
Spacecraft	—	—
Ground support	0.4	—
TOS improvements	3.3	2.6
Total spacecraft and support	3.7	2.6
Delta (launch vehicle procurement program)	(—)	(—)
TOTAL (including launch vehicles)	(3.7)	(2.6)

METEOROLOGICAL FLIGHT EXPERIMENTS

	1966	1967
TOTAL	3.9	5.5

NIMBUS

	1966	1967
Spacecraft	11.7	9.5
Experiments	4.8	9.9
Ground operations and support	3.3	4.0
Total spacecraft and support	20.0	23.4
Thor-Agena (launch vehicle procurement program)	(3.7)	(5.3)
TOTAL (including launch vehicles)	(23.7)	(28.7)

METEOROLOGICAL SOUNDINGS

	1966	1967
Large research sounding rockets	1.9	1.9
Sounding rocket system development	0.6	0.6
Field experiment support	0.4	0.4
TOTAL	3.0	3.0

COMMUNICATION & APPLICATIONS TECHNOLOGY SATELLITES

	1966	1967
TOTAL Supporting research and technology	4.5	4.6

APPLICATIONS TECHNOLOGY SATELLITES

	1966	1967
Spacecraft	24.8	17.8
Operational support	3.1	4.0
Total spacecraft and support	28.0	21.8
Atlas-Agena (launch vehicle procurement program)	(8.2)	(12.8)
TOTAL (including launch vehicle)	(36.2)	(34.6)

as electric power, reaction control, communications, propulsion, landing gear, and environmental control.

The first flight-rated LEM will be completed, delivered to Cape Kennedy and launched in the same fiscal year. Ten additional LEM's will be in the manufacturing and checkout phase, and by the end of the year two will be delivered to Cape Kennedy.

The balance of next year's spacecraft and launch-vehicle request for Project *Apollo* is all earmarked for the near-completion of ground testing and the delivery of flight-rated vehicles to the launch site at Merritt Island, Fla. This is a clear indication this country is moving closer to achieving its goal of landing a man on the Moon by the end of this decade.

The space agency said that its request for supporting development for Project *Apollo* would be used primarily to develop backup systems including a small-thrust engine to provide attitude control. A large portion of the funds will be used to develop hardware to replace *Apollo* spacecraft counterparts with minimum disruption, should replacement be necessary.

New concepts—In the advanced manned mission study area, NASA said that distribution of the $8-million budget would provide the Manned Spacecraft Center with $2.6 million; the Marshall Space Flight Center, $4.5 million; Kennedy Space Center, $600,000; and NASA Headquarters, $300,000.

It said the FY '67 effort would be directed at preliminary systems definition of the more promising space station concepts—including a long-term station not requiring supply and launched by the *Saturn V* and an optimized space station capable of supporting planetary flight.

Particular attention will also be given to the description and definition of experiment modules which can be used in conjunction with the various concepts.

Systems definition of an extended lunar exploration plan will also be emphasized. This will include comparative evaluation of various delivery and mobility systems.

The space agency said that highest on the list of its future unmanned exploration flights to the planets is Jupiter. Fiscal '66 funds were spent to determine what technology would be required to achieve such a mission and money in the next fiscal period will be used to fund plans to develop the technology.

The request will also be spent to survey other future missions and the generation of concepts for exploration of the Moon, Venus, Sun, comets and asteroids. In addition, a preliminary study will be conducted to determine feasibility of a probe to Saturn. ■

Decision Near on Target Vehicle for Gemini 8 Flight

NASA IS EXPECTED to decide on Feb. 14 whether it will use the *Alternate Target Docking Adapter (ATDA)* or the *Agena Gemini* Target Vehicle in the upcoming *Gemini 8* mission.

If the *ATDA* is chosen as the rendezvous target vehicle, earliest launch date for the two-day flight would be March 7. If the *Agena*—which exploded during the *Gemini 6* mission on Oct. 25, 1965—is ruled ready for the mission, the launch will be attempted a week or so later.

Officials say that current planning provides for possible use of either of the vehicles as the target for the *Gemini 8* crew of Command Pilot Neil Armstrong and David R. Scott.

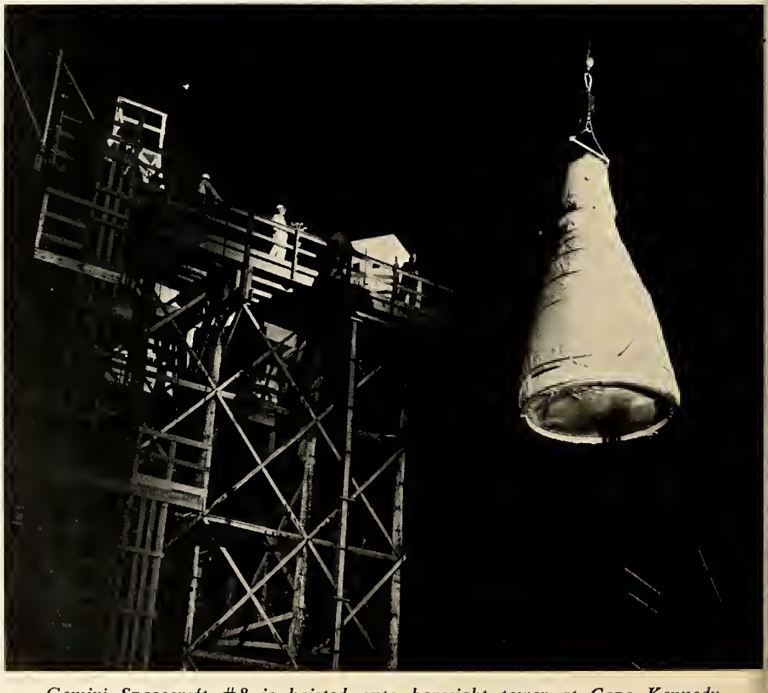
Manned Spacecraft Center and NASA Headquarters officials traveled to the McDonnell Aircraft Corp. plant in St. Louis last week for an acceptance review of its status. Reportedly, no problems have developed and the vehicle is right on schedule. There was no word late in the week, however, as to whether it had been officially accepted.

At the same time, it was learned that NASA has moved up the start of the high-altitude vacuum tests of the *Agena* target vehicle at the Arnold Engineering Development center at Tullahoma, Tenn. to early this week. Originally, the crucial series of tests—which will simulate flight at the altitude at which the *Agena* exploded—was not scheduled to start until late this month.

Thus far, NASA said, the modifications to the *Agena* engine which were made in an effort to prevent another explosion have been successful and nothing has cropped up in the ground-test program to indicate there may be trouble in the future.

The *Gemini 8* spacecraft hard-mating with the *Titan II* booster on pad 19 at Cape Kennedy is expected this week. The *Alternate Target Docking Adapter,* after intensive checkout at McDonnell Aircraft Corp., was scheduled for delivery to the Cape last weekend.

In the meantime, the *Gemini 9* spacecraft will begin altitude checkout this week in the McDonnell space chamber. ■



Gemini Spacecraft #8 is hoisted onto boresight tower at Cape Kennedy.

NAS Urges Solar Observatory Work

Report calls AOSO 'indispensable'; development of large orbiting telescopes, astronomy satellites, sounding rockets stressed

by Heather M. David

A GROUP OF SCIENTIFIC advisors to NASA are pressing for a step-up in the *Orbiting Solar Observatory (OSO)* and *Radio Astronomy Explorer (RAE)* programs, and doubled emphasis on the sounding rocket program for space and solar astronomy.

In addition, the group has called for initiation of development of an 120-in. optical telescope and an orbiting radio telescope with an aperture of 20 km. The recommendations were made by the Space Science Board of the National Academy of Sciences in a recent report to the space agency.

An interesting sidelight to the report is the fact that the scientists stressed that the *Advanced Orbiting Solar Observatory (AOSO)* program is "an indispensable next step in NASA's solar program and must be flown close to the coming solar maximum." Contrary to the board's recommendation that "the *AOSO* program be accorded all the priority necessary to maintain the launch schedule as shown in the prospectus"—which called for a 1969 launch—NASA was forced to cancel or at least postpone the project because of budgetary reasons.

Optical astronomy—During the next 10 years, the Space Science Board said, NASA should double the number of coarse-pointing sounding rockets for optical space astronomy, as well as include two or more telescopes with apertures of 40 in. or larger in the *Apollo* Extension Systems—now *Apollo* Applications Program (AAP). Effort also should go into development of various detectors required in space telescopes, improved gratings, optical interferometers, and research and development concerned with problems of space telescope optics, especially with the primary mirror.

The group also called for increased support of ground-based astronomy to ensure the healthy growth of astronomy in general and space astronomy in particular.

For the future, however, the national effort in optical space astronomy should be in the direction of a very large orbital telescope for use with a wide variety of astronomical instrumentation. Resolution should correspond to an aperture of at least 120 in., detecting radiation between 800 Angstroms and 1 mm.

This instrument, the board said, would require the capability of man in space. However, it is becoming technically feasible and "will be uniquely important to the solution of the central astronomical problems of our era."

The group suggested that an *ad hoc* panel be appointed by the Space Science Board to work toward the large orbital telescope and encourage studies of pacing areas of R&D.

A proposed schedule for the telescope called for funding to begin in 1966, preliminary design studies in 1967, breadboarding the following year and launch on a *Saturn V* in 1979.

Solar astronomy—In this field, the scientists echoed the request for step-up of the sounding rocket program with attention to development of triaxially stabilized rocket attitude controls leading to fine-pointing systems.

Four additional *OSO* satellites were recommended, and NASA was cautioned not to terminate the *OSO* program after 1972 without further review.

Although the scientists said that the Astronomical Telescope Orientation Mount (ATOM) in the AAP "merits vigorous support," they emphasized that manned missions might supplement *AOSO* but "cannot replace it."

Future studies should include orbiting solar telescopes of at least 1-meter aperture designed to obtain a resolution of 0.1 sec. of arc at visible wavelengths and 0.5 sec. of arc at far-ultraviolet wavelengths. Feasibility and design studies for such telescopes should begin immediately, the group said.

Radio and radar astronomy—Launch schedule for *Radio Astronomy Explorer* satellites should include at least one per year, the board said. At least two *RAE* satellites should be instrumented for long-wave solar radio observation in space near sunspot maximum to provide data on the low-frequency characteristics of solar radio bursts.

The ultimate device, however, would be a space radio telescope with an aperture of the order of 20 km (approximately 12 mi.). Again, a panel appointed by NAS was suggested to study possible conceptions of such a radio telescope and to initiate studies of the scientific and engineering problems connected with its construction.

In the meantime, the board suggested work leading to a high-resolution broad-band antenna system, to be flown in about two years, for observations in the frequency range from 10 MHz to a few hundred kHz.

Increased use of ground facilities and balloon flights were recommended for astronomical observations of all types. For X-ray and gamma-ray observations alone, the board foresaw a need for at least 40 balloon flights per year and development of new balloons with a payload capability of 250 lbs. to 145,000 ft. altitude and 2,000 lbs. to 130,000 ft.

X-ray and gamma-ray astronomy—The scientists said that X-ray experiments should now be considered even as substitutes for other *Orbiting Astronomical Observatory* experiments, and consideration should be given to setting aside an entire vehicle for X-ray and gamma-ray observations.

They also called for doubling the number of rocket flights and recommended the engineering development and construction of a prototype of a controllable star-guide orientation system with an accuracy better than 1 min. of arc.

An attempt at measuring the diffuse radiation flux of energies greater than 100 mev by small *Explorer*-type satellites also was recommended.

Physics and geophysics—Relativity and gravitation are the critical subjects of space studies in physics and geophysics, the working group said.

One necessary element, the scientists said, is development of a suitable high-precision radar altimeter and studies relating to precise height sensors and gradiometers which could be used to measure a host of significant physical parameters of the dynamic Earth, and then applied to study of other planets.

Corner reflectors on the Moon would open up prospects for a variety of experiments, the board said, as would reflectors on long-lived satellites.

In general terms, the group saw most of the observation done by unmanned vehicles, with man relegated to an assembly or maintenance function. However, the group outlined a number of experiments which could be performed during manned missions, and asked for inclusion of more scientists in the astronaut program. ■

velops 21,900 lbs. of vacuum-rated thrust.

First Saturn IB Launch Will Test Apollo Heat Shield Design

by Jinx Mercer

Houston—The first "all up" test of the *Saturn IB* launch vehicle and the *Apollo* spacecraft on Feb. 22 will also be the first of four flights to qualify the Command Module heat shield for the lunar mission.

Glynn S. Lunney, flight director for the *Apollo-Saturn 201 (AS-201)* mission, said the first two flights *(AS-201, AS-202)* will experimentally verify analytical data and engineering assumptions used to design the lunar spacecraft heat shield. From these two flights, designers hope to extrapolate calculations on thermal loads and rates expected during higher-velocity re-entries of 36,000 fps.

In addition, plans call for verifying the lunar heat shield in the first two 500-series flights *(AS-501, AS-502)* in early 1967, using the *Saturn V* launch vehicle to ram the Command Module at full velocity through Earth's atmosphere in a simulation of re-entry from lunar-mission altitudes.

Less than lunar—Lunney said that re-entry speeds during *AS-201* and *AS-202* missions will be about 9,000 fps less than the lunar re-entry speeds. *AS-201* will be a steep re-entry with the Command Module heat shield planned for full-lift capability to encounter high heating rates. The spacecraft will be rammed back through the atmosphere with 3,000 fps additional thrust supplied from the Service Propulsion System (SPS) engine.

AS-202 will be a shallow re-entry to encounter high heating loads. The vehicle will be "skipped" at one point along the re-entry profile nearly back to entry altitude (400,000 ft.) to dissipate heat loads, then continued on a shallow re-entry to splashdown. Its trajectory will take the spacecraft nearly two-thirds of the way around the world to a Pacific landing.

The new launch vehicle is an uprated *Saturn I* that has been demonstrated in 10 successful flights, Lunney said. It includes a new S-IVB second stage with one J-2 engine.

The *Apollo* spacecraft (009) will be launched by the *Saturn IB* launch vehicle from complex 34 on Merritt Island. The *AS-201* launch profile will be identical to the manned mission profile, Lunney said. After the second stage is ignited, the *Apollo* launch escapc system with boost protective cover will be jettisoned. This, he said, will place the vehicle into the region of SPS abort mode, which uses thrust from the Service Module engine to make up for large launch vehicle errors.

Structural loading and booster-spacecraft compatibility data during the launch phase of flight will be collected by a special instrumentation unit in the spacecraft's Lunar Excursion Module (LEM) adapter. Data on separation performance will be collected by ground camera, telemetry, and radar.

Powered-flight cutoff will occur at approximately 150-n.-mi., but the vehicle will coast through apogee (250 n. mi.) in pitch-down attitude—in position for Service Module engine firing.

Crucial timing—A critical "go/no go" decision will be made 20 to 30 seconds after second-stage cutoff, Lunney said. This will be to evaluate cutoff for launch-vehicle guidance inaccuracies prior to initiating the on-board control programmer 30 sec. later to carry out all follow-on mission functions. The abort programmer, in the meantime, will be in "standby" position to initiate the SPS abort mode in the event of an earlier-than-nominal booster cutoff, he explained.

At one minute after second-stage cutoff, the Mission Control Center will send up a signal via a tone command to start the control programmer. The programmer, which automatically performs all the functions that normally would be handled by the crew, consists of three electronics units: radio command control, automatic command control and a sequential timer. (The tone command system will be used only on the *AS-201* flight, Lunney said. Subsequent *Apollo* flights will use the digital command system.)

Near apogee, the reaction control system thrusters will be fired to seat propellants over exit nozzles leading to the SPS engine thrust chamber. This 30-second ullage maneuver will be followed by a three-minute burn of the SPS engine. SPS engine performance will be monitored via telemetry for firing stability, extended-duration operation and shutdown characteristics.

The pressure-fed, ablatively cooled SPS engine burns storable propellants—aerozine 50 fuel, a 50-50 mixture by weight of unsymmetrical-dimethyl hydrazine (UDMH) and hydrazine with nitrogen tetroxide as oxidizer. It develops 21,900 lbs. of vacuum-rated thrust.

Second burn—After a 5-sec. coasting period, the ullage rockets will be fired to seat the propellants prior to the second SPS engine burn of approximately 10-sec. duration. This will be a test of the engine's restart capability. The SPS engine is designed for up to 50 separate engine starts in space and a total burning time of 12.5 min.

The spacecraft will then be oriented into a pitch-up attitude and the Service Module will be explosively severed from the Command Module. The control programmer will sequence the Command Module attitude control and stabilization system thrusters to maintain tight attitude within a deadband of ± 0.5 degrees during re-entry. A roll rate will be initiated to cancel lift which has been induced by offsetting the spacecraft's center of gravity.

Inertial velocity at entry (400,000-ft.) altitude will be approximately 27,500 fps, according to Lunney. Most of the major heating occurs in a band of altitudes between 270,000 and 200,000 ft. A slight "skip" has been programmed within this band to dissipate some of the heat rate. Lunney said the spacecraft will climb approximately 15 n. mi. in altitude before resuming its downward path.

The trajectory for the *AS-201* mission is designed to impose a maximum load factor of 15 g on the spacecraft and a maximum total heat rate of approximately 200 Btu/ft.^{2}/sec. Heat-shield data will be collected onboard the spacecraft on a tape recorder.

Tracking—The Mission Control Center (MCC) will be receiving telemetry data up through separation, Lunney said. The mission plan calls for the vehicle to be positioned for the first SPS firing before the spacecraft moves out of communications range.

The Rose Knot Victor (RKV) tracking ship will be deployed midway along the 4,750-n.-mi. ground track and will have both telemetry coverage and command capability. There will be a two-minute communications gap between MCC loss-of-signal and RKV acquisition-of-signal. RKV controllers expect to acquire the vehicle approximately two minutes prior to SPS engine firing, Lunney said. The ship will monitor control of gimbal motor actuators, which provide the SPS with pitch and yaw attitude control.

The 35-min. flight will end near Ascension Island. "We hope to get a good radar track from the island tracking site to predict the spacecraft's impact point," Lunney said, "but we expect larger impact point dispersions in *Apollo* than in *Gemini* landings." The spacecraft will be "on chute" about 30 min. into the flight.

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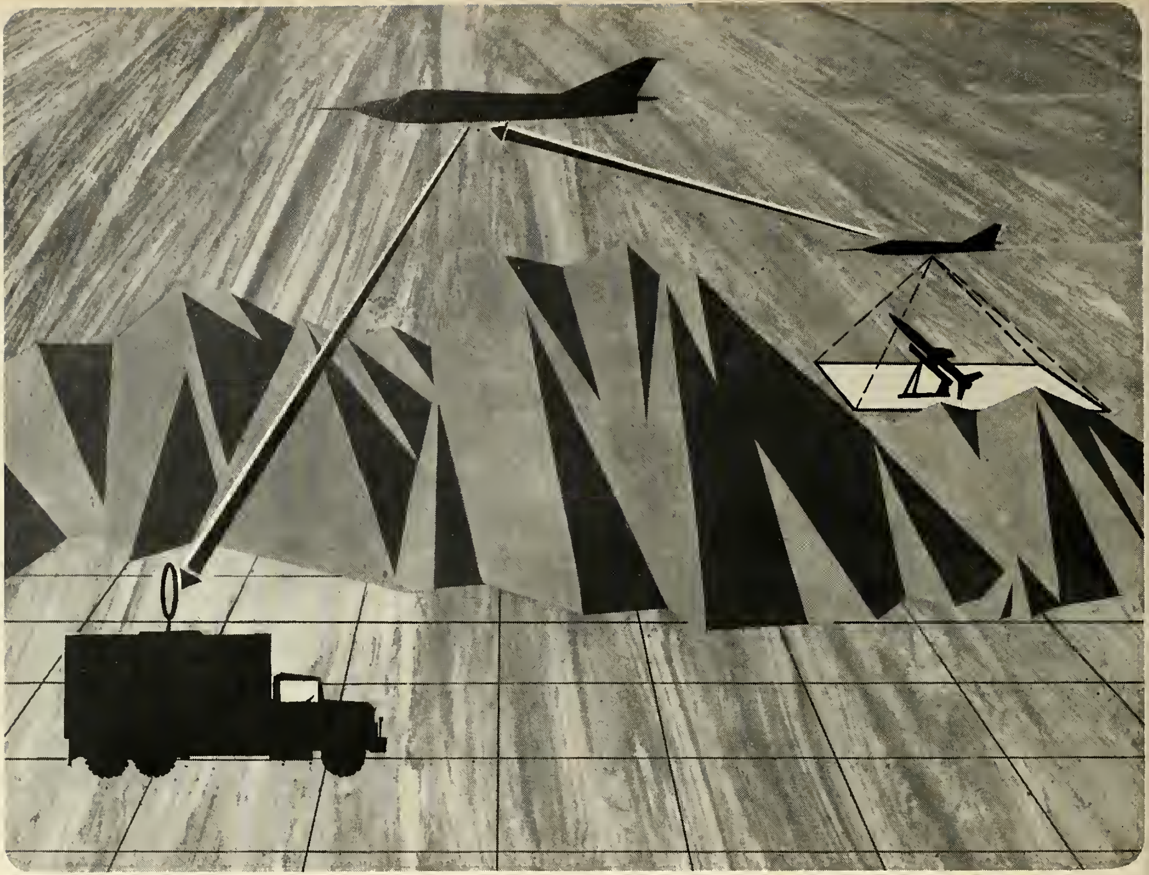

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Technical Countdown

MATERIALS

Boron Filament Structure Studied

A program that could lead to an aircraft box beam of boron composites is under way at the Los Angeles Div. of North American Aviation, Inc. Funded by the Air Force Material Laboratory, the seven-month program is one of five to explore the potential use of boron composites on unmanned re-entry vehicles, helicopter rotor blades, gas turbine engines, and aircraft structures. An aircraft box beam made up of this material is expected to be stiffer, stronger, and weigh 35% less than a conventional aluminum structure. The boron filaments used are formed by the chemical vapor deposition of boron onto a 0.0005-in. tungsten core. Composites are formed by combining the 0.004-in. filaments in a plastic or metallic binder material.

Hypervelocity Impact Results Evaluated

A variety of typical target materials has been subjected to hypervelocity impacts in experiments at IIT Research Institute under a program sponsored by Lockheed Missiles and Space Co. A light gas gun was used to launch lethal particles at velocities of 20,000 fps. The dynamic target deformation process occurring at impact was observed using high-speed flash-radiography and a new high-speed streak camera technique developed at IITRI. The data obtained will be used to design new and improved target materials.

Magnetic Nuclei Used as Coolant

Researchers at the University of California, San Diego, have successfully used magnetic nuclei as a coolant. The use of the magnetism of the atomic nuclei rather than the electrons is another form of adiabatic demagnetization, a technique first developed in the 1930's and recently used to produce temperatures down to 0.002°K. The magnetic nuclei approach can theoretically reach temperatures down to 10^{-6} degree K. University researchers have now reached 0.003°K, starting from a temperature of 0.013°K and a field of 57 K gauss. The cooling substance was commercial copper wire. This is not a record low temperature, but the older adiabatic demagnetization techniques cannot produce temperatures much lower. Lower starting temperatures, different materials and smaller heat leaks will lead to much lower temperatures with nuclear cooling. The new temperature ranges possible are a factor in the study of the quantum mechanical processes leading to superconductivity in metals and superfluidity in liquid helium.

Laser Hole-Drilling Perfected

Masor Optics, Inc., has developed a technique for laser-drilling of perfectly round roles in any material—including diamonds. The holes do not require any additional machining or polishing. A patent application has been submitted covering the method. Details may be obtained from Dr. Harry E. Franks, president, Maser Optics, Inc., 89 Brighton Ave., Boston, Mass.

ELECTRONICS

New Microwave Oscillating Diode Developed

Sylvania Electric Products, Inc., is now marketing a microwave oscillating diode (MOD) that will allow weight reductions of up to 98% in microwave power sources. The unit also virtually eliminates all the heat created in present microwave generators using low-power klystrons or magnetrons. About the size of a sharpened pencil point, the device is reported to be the first commercially available unit guaranteed to provide a specified level of microwave power output when excited by direct current. The MOD D5540 provides a minimum power output of one milliwatt for frequencies from X to Ku bands. The MOD has a high dc-to-rf conversion efficiency. It is possible to generate two to three milliwatts of microwave power while dissipating only 300 milliwatts dc power for an efficiency of 1%. A klystron source having a similar power output might dissipate 10 watts for a 0.03% efficiency.

PROPULSION

Monopropellant Motor Hits 250 lbs. Thrust

A hydrazine monopropellant rocket motor using the Shell 405 spontaneous catalyst has been successfully test-fired by engineers at Walter Kidde & Co., Belleville, N.J. The unit reached a peak thrust of 240 lbs., making it the largest motor fired to date using the Shell catalyst. The new motor complements units in the 2-, 8-, 22- and 50-lb.-thrust regimes that have been tested and are available. Kidde supplies the reaction-control components and systems for *Syncom*, *Early Bird*, 303A *Bluebird*, *ATS*, *Scout*, *Little Joe II*, *SATAR*, Burner II, NASA's Lunar Landing Vehicle, *ASSET*, *MMU* and another classified program.

Navy Satellite To Use Subliming Rocket

A valveless subliming solid control rocket will be designed and developed for the Office of Naval Research by Rocket Research Corp. under a $49,577 contract. The unit will have a thrust level in the one-millionth-pound area. The new unit is being designed for a three-axis, gravity-gradient-stabilized satellite. The control rockets will be positioned along the flight line; addition or subtraction of energy will make possible small orbital adjustments. The thrust level must be extremely low to prevent excessive deflections of the booms attached to the satellite to provide gravity-gradient orientation.

BIOSCIENCE

Interstellar Dust Hydrocarbonaceous?

Recent spectroscopic studies by Dr. Fred M. Johnson of Electro-Optical Systems, Inc., indicate that interstellar dust may actually consist of hydrocarbons. Johnson told a physicists meeting that the dust particles, which impart a red hue to stars, are actually various compounds of hydrogen, carbon and nitrogen, instead of ice and graphite. Johnson hypothesizes that these grains probably have either atoms or electrons missing and thus escape identification on Earth since they do not ordinarily exist in the same form in the laboratory. Further spectroscopic experiments will be conducted at EOS and perhaps in space to validate the findings.

Avco Studies Blood Fluid Dynamics

Avco Everett is studying the fluid dynamics of blood and the mechanisms of clotting under a contract from the Air Force Office of Scientific Research. The program will include theoretical and experimental studies of hydrodynamic factors affecting thrombus formation and blood clotting, flow time and shear studies. The work is an extension of Avco's fluid dynamics experience in other fields, company officials say.

Technique Ranks Space Objectives

Honeywell's PATTERN uses voting sessions, computer and new management structure to find 'most valuable' experiments

by William S. Beller

HUNTSVILLE, ALA.—In a Marshall Space Flight Center project just completed, space experiments proposed for launch are analyzed on a computer and ranked according to how much each could contribute to NASA's overall space objectives.

NASA could eventually use the technique to compare not only experiments but also entire projects. Would a lunar base be worth more to NASA than a Mars orbiter, for example? Or, how much would a large orbiting telescope negate the need for further planetary programs?

Nobody suggests that the technique will make decisions, but "it certainly would be a remarkable aid for decision-makers," Dr. H. O. Ruppe, MSFC scientist told MISSILES AND ROCKETS.

The opinion of experts suitably challenged, a computer, and an embracing structure comprise the system inputs.

The structure is called PATTERN—Planning Assistance Through Technical Evaluation of Relevance Numbers. It was devised by Honeywell Military Products Group several years ago to help in corporate R&D planning. It was subsequently refined and adapted to some of NASA's problems related to ranking possible space experiments. "We are now evaluating the concept," said Walter H. Stafford, technical monitor of the work for MSFC.

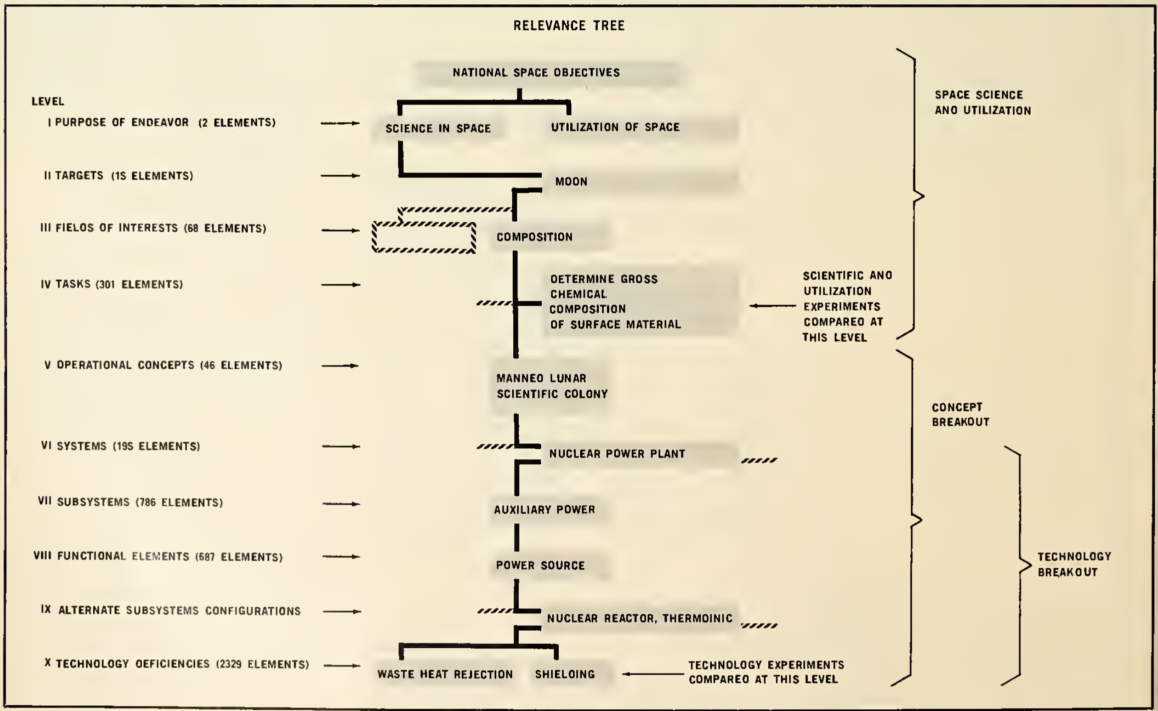
It was clear from conversations at MSFC that the next problem with respect to PATTERN will not be technical but one of teaching the system to people and showing them its value.

Since thousands of variables must be sorted, ordered, manipulated and kept current for PATTERN, a computer is essential. The present program uses a Burroughs 5500 at MSFC. Computer language is COBOL.

How to be an expert—Honeywell engineers Richard H. Parvin and William C. Sproull said the only way to really understand what PATTERN entails is to participate in one of the voting sessions. They quickly organized one with two NASA engineers and myself as the voters, Parvin as moderator and Sproull as the "computer."

Parvin stressed that this was only a "sampler" session. Actual ones have 10 or possibly 20 participants, all having done some orientation reading.

Our job was to decide the relative emphasis NASA should put on future programs in space science and space utilization in the light of the agency's space objectives. This means that current space programs would not affect


RELEVANCE TREE
LEVEL
I PURPOSE OF ENDEAVOR (2 ELEMENTS)
II TARGETS (15 ELEMENTS)
III FIELDS OF INTERESTS (68 ELEMENTS)
IV TASKS (301 ELEMENTS)
V OPERATIONAL CONCEPTS (46 ELEMENTS)
VI SYSTEMS (195 ELEMENTS)
VII SUBSYSTEMS (786 ELEMENTS)
VIII FUNCTIONAL ELEMENTS (687 ELEMENTS)
IX ALTERNATE SUBSYSTEMS CONFIGURATIONS
X TECHNOLOGY DEFICIENCIES (2329 ELEMENTS)
NATIONAL SPACE OBJECTIVES
SCIENCE IN SPACE
UTILIZATION OF SPACE
MOON
COMPOSITION
DETERMINE GROSS CHEMICAL COMPOSITION OF SURFACE MATERIAL
MANNED LUNAR SCIENTIFIC COLONY
NUCLEAR POWER PLANT
AUXILIARY POWER
POWER SOURCE
NUCLEAR REACTOR, THERMOINIC
WASTE HEAT REJECTION
SHIELDING
SPACE SCIENCE AND UTILIZATION
SCIENTIFIC AND UTILIZATION EXPERIMENTS COMPARED AT THIS LEVEL
CONCEPT BREAKOUT
TECHNOLOGY BREAKOUT
TECHNOLOGY EXPERIMENTS COMPARED AT THIS LEVEL

SAMPLE PATTERN BALLOT

	MATERIAL BENEFITS TO MANKIND 0-10 YEARS	MATERIAL BENEFITS TO MANKIND 10-20 YEARS	PRESTIGE	IMPROVED KNOWLEDGE	TOTAL RELEVANCE
	0.40	0.15	0.15	0.30	1.00
SPACE SCIENCE	0.20 (0.40 x 0.20 = 0.08)	0.65 (0.15 x 0.65 = 0.098)	0.50 (0.15 x 0.50 = 0.075)	0.75 (0.30 x 0.75 = 0.225)	0.478
SPACE UTILIZATION	0.80 (0.40 x 0.80 = 0.32)	0.35 (0.015 x 0.35 = 0.052)	0.50 (0.15 x 0.50 = 0.075)	0.25 (0.30 x 0.25 = 0.075)	0.522

our recommendations except as we saw these programs giving rise to new ones.

Parvin gave each of us a blank ballot of the type shown here. Listed across the top are the criteria we were to use, descriptive of NASA's space objectives:

—Attain material benefits for mankind within the next 10 years.

—Attain these benefits within 10 to 20 years.

—Increase the country's prestige in the eyes of the governments and peoples of the world, and the international scientific community.

—Increase human knowledge for its own sake but not for any clearly identifiable material benefits.

If we felt that one or more of these suggested criteria were unimportant, we could rate them so in our voting. On the other hand, if we felt other criteria were very important, but missing, we could include them and give them a high rating.

Thus, the relative importance of each criterion would be reflected in the ratings we assigned. The sum of the ratings had to equal 1.0—the total relevance of the criteria.

Value stressed—Before the first round of voting, Parvin advised each of us to make "value" decisions. "Decide which courses of action have the highest intrinsic worth consistent with the present state of the art in space science and applications," he said.

The votes of one of the participants will be taken as typifying the procedure. He gave the following ratings to the respective criteria: 0.60, 0.10, 0.00, 0.30. This was a secret ballot, revealed only after everybody had voted.

The most important part of the procedure now became apparent. Each participant had to defend his ratings and be ready to change them if he felt another participant had given data either not considered or not considered enough. Yet a participant was not to bow to consensus if he truly believed his ratings were valid.

The participant who rated prestige at zero explained that this factor would be a natural fallout of the other criteria and hence did not deserve its independent listing. He was reminded that NASA opens all its launches to the press for reasons explained chiefly by the prestige factor, moved up the *Gemini* spacewalk to counter the earlier one by a Soviet cosmonaut and, in fact, was pushed into the space age for the loss in face this country suffered when *Sputnik I* was launched.

On his second balloting, the participant changed his ratings to 0.40, 0.15, 0.15, 0.30.

Summing up the process, Parvin said, "See if you feel your ratings reflect your own opinion—and then see if the other voters are out of line, and argue with them, but don't compromise. The object of the voting is not to convert others but to reach the best within yourself."

Science versus use—We next determined where NASA's emphasis should be to effectively achieve each of the listed criteria. One participant, considering the prestige factor, suggested that NASA put 20% of its effort on space science and 80% on space utilization. In the discussion that followed the first voting, he confessed thinking of prestige only in terms of applause from the international scientific community and had forgotten the tremendous "lay" prestige the U.S. gained from the *Ranger* Moon pictures and *Mariner* Mars pictures. He changed his rating to 50%-50%.

The result of this one participant's try at making policy for NASA indicated that 47.8% of the agency's emphasis should be on space science programs and 52.2% on space utilization if NASA's space objectives are to be effectively reached.

A group of Honeywell engineers taking the same test indicated an opposite emphasis: 52.4% on space science, 47.6% on space utilization. The reason, said Parvin, is that the Honeywell group had averaged its scores, had read a great deal of source material before taking the test, and had much more time for discussion. Another factor may have been the bias built into a group working for the same organization.

Asked if he saw deviations in voting patterns within the groups he tested, Sproull said that final votings almost always showed clusters around the same points. He interpreted this as indicating objectivity among the voters and a structured way to reach decisions with knowledgeable people.

Levels of endeavor—The way the relative emphasis or "relevance numbers" were derived for space science and space utilization is further used to get the relevance numbers of space targets within these two categories. In turn, these space targets are further subdivided until a level is reached at which individual technical problems are considered.

The voting therefore takes place on various levels, the first concerned with policy questions and later levels with the technical details. Voters at the various sessions are chosen with regard to their specialized knowledge. Administrators would deal with policy questions, and propulsion men, for example, with assigning relevancies to propulsion subsystems.

To go from major policy to detailed design, Honeywell uses 10 levels. Here's how the system would work. A scientist suggests an experiment, possibly to measure the charge distribution in Jupiter's magnetosphere. This work would contribute to the task of finding the gross composition of the magnetosphere of Jupiter.

How many other tasks would this experiment benefit? How much information could it contribute to each? And what is the relevance of each task? PATTERN, in terms of its levels of relevance—in aggregate called "relevance tree"—and relevance numbers, presumably would give the answers. The relevance number of the experiment itself would be found and compared with the numbers of other suggested experiments, even in other domains. Knowing how important the Jupiter experiment is in the overall pattern of NASA's objectives, the program manager would perhaps have an easier time making up his mind about accepting it or choosing another.

In other words, the total relevance of an experiment reflects the number of scientific or technical tasks it could contribute to, their importance, and the number of technical deficiencies it might satisfy.

The relevance numbers do not tell how good the experiment itself is, whether the experiment will work, whether the experimenter is competent, is charging too much, will have his experiment ready on time, or if the experiment will mix well with other payloads. This last factor is the subject of another MSFC study.

Ten levels explained—The first level in the relevance tree is made up of the two elements voted on earlier, which reflect the purpose of NASA's work: space science and space utilization.

Level II indicates the chief targets of interest for the upper two branches of the relevance tree. Space science targets, for instance, include the Moon, Mars, comets, Sun and other bodies; space utilization targets involve using the vacuum environment, radiation environment and other space environments for practical ends.

In turn, Level III is made up of the fields of interest of each of the targets called out in Level II. The lunar field of interest, for example, involves studies of the Moon's atmosphere and ionosphere, biology, composition, magnetosphere and radiation belts, and geodesy and mapping. On the utilitarian side, the vacuum field of interest contains manufacturing, biological work, transportation, and R&D laboratories.

At Level IV, tasks are called out that are needed to support the fields of interest of Level III. Included under the lunar composition field of interest, for instance, are such scientific tasks as IR surface mapping, study of gross physical surface characteristics, and study of lunar outgassing.

The four levels just described make up the "upper half" of the tree and are used to structure the general targets and problems of space exploration and exploitation. The remaining six levels are specific in terms of missions, systems, and hardware.

Level V is made up of a sampling of concepts and missions, not now in the budget, that appear feasible within the next 20 years.

Level VI identifies the systems needed to support the concepts and missions. For example, a synchronous meterological satellite consists of three systems: booster, spacecraft, and ground support facility.

Systems are divided into subsystems in Level VII. Subsystems of a manned lunar orbiter, for instance, include auxiliary power, life support, communications, and the vehicle.

Level VIII calls out the functional elements of the subsystems. For life support, for instance, major functioning elements would be needed for air, water, food, temperature-pressure-humidity control, and medical/psychological monitoring.

The two remaining levels suggest, in turn, a choice of technical solutions to the problems of the functioning elements, and technical deficiencies that must be filled for these solutions to be practicable. Thus, on Level VIII, a functional unit could be a power source; on Level IX, a technical solution might involve a solid-core nuclear engine or a gaseous-core nuclear engine; and on Level X, the technological deficiencies of the gaseous-core nuclear engine would be named: thrust vectoring, cool-down and start-up capability, and nuclear shielding.

The lower half of the tree thus outlines a proposed mission, discusses its design, and fingers its problems. Where a number of proposed missions have the same technical problem, such as the need for high-temperature materials, and the missions have high relevance, the problem becomes increasingly important to solve. Its importance with respect to other problems is given in terms of its relevance number.

In terms of a particular experiment, its value is determined by the product of its probable contribution to the task or deficiency and the relevance or importance of that task or deficiency. The contribution of an experiment to a task is found in the same manner relevancies are found, that is, by voting and discussion.

To keep PATTERN current, the computing system is arranged to accept new data as they arise, and print out updated experiment relevancies and rankings.

A marriage—"At present, there is no rational procedure for mating experiments with space vehicles," said MSFC scientist Ruppe. Yet the PATTERN work plus that of General Dynamics/Fort Worth might set up a feasible procedure, Ruppe noted.

He described the GD/FW work as a system for measuring the compatibility of experiments with launch vehicles. Admittedly, "it's a rough cut at the problem," he said, but does take into account mission profile, other flight parameters, payload volume and location. "We won't find ourselves assigning a one-cubic-foot experiment to a half-cubic-foot volume," he said, "or putting a lunar drill on an Earth-orbiting mission."

The hope is that a computer will eventually match highly relevant experiments to appropriate launch vehicles.

PATTERN itself suffers limitations in its present state. If for some reason an experiment is eliminated from consideration, there is no feedback to show how this will affect the relevancies of other experiments. Also, the performance of a given experiment might nullify the need for a different experiment, but PATTERN as yet provides no printout for this. Parvin says the next phase of PATTERN work possibly will.

An instance of the value of PATTERN would be to avoid reaching seemingly biased conclusions such as those of the Space Science Board, National Academy of Sciences-National Research Council. In a recent report on planetary and lunar exploration, the board advised, "the prime goals of the nation's space programs should be the elucidation of . . . fundamental cosmological and biological questions." This may be true as far as space science is concerned, but not necessarily true if the practical utilization of space is also considered.

Clearly, the PATTERN technique is new only in the structuring of many variables into units that can be handled and comprehended. Like PERT, the logic of the system has always been with us. But now the modern structure permits deeper analyses of management problems.

An extended use of PATTERN, once it is able to find weighted relevancies for entire programs instead of experiments alone, would be to help evaluate major efforts suggested by any government agency. The start would define agency goals in the widest sense, and then see how proposed efforts could contribute to these goals. This is the method Honeywell used for its NASA work. Based on the efforts with the highest relevancies, the worth of individual programs could be calculated.

Making an agency's goals specific might be an added PATTERN dividend.

The method could also be used in presenting evidence in Congressional hearings. Rep. Joseph E. Karth (D-Minn.), ranking member of the House Space Committee, told M/R last year that he could dearly use some yardstick to measure the relative merits of proposed space programs. He told of getting much testimony but it reflected the views of only the witnesses and his departments, after filtering through appropriate Administration officials. PATTERN, perhaps, could give more objectivity to the evidence and cut through some of the filters. ■

Belgian Defense Firm Diversifying

Work on consumable and combustible cartridge cases opens way to development of fiber-molded commercial products

by John F. Judge

HERSTAL-LIEGE, BELGIUM—An old-line Belgian defense firm will use a new U.S.-licensed process for the production of consumable and combustible cartridge cases as a springboard into its first commercial products.

S. A. Les Forges De Zeebrugge, under the management of Jean H. Depouhon, is now developing five different calibers of artillery shell cases using the new process for various European military departments. The experience acquired through these programs will be used in 1967 to launch a determined program to develop various fiber-molded products for automotive and other civilian industries.

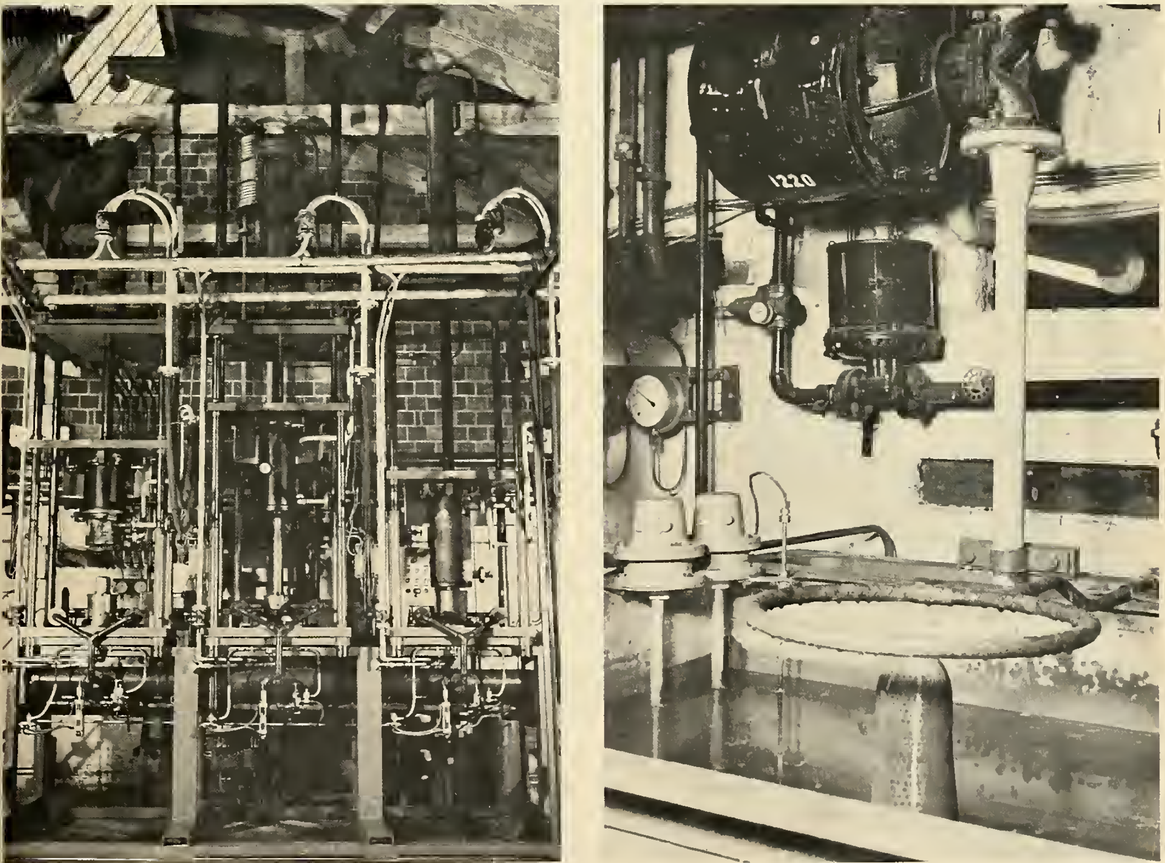
The process itself is licensed from Hawley Products, St. Charles, Ill., but Zeebrugge incorporates many significant changes in the compositions and case designs. These are necessitated by the various customer requirements.

The French, for instance, do not want fully combustible cases. They prefer to keep the nitrocellulose content low.

All of these cases are formed from nitrocellulose fibers in conjunction with other wood fibers and resins.

Zeebrugge has installed a three-press production unit in a large, spacious plant in Herstal. There is ample room for additional base units. The initial part of the process consists of preparing a water slurry of the desired fibers. This

Three-press consumable-combustible cartridge case production unit at Zeebrugge shows artillery case die in center press. Felting tank is immediately behind presses. Vacuum cartridge case die is lowered into felting tank. Ring washes die as it slides down.



Left: Assembly area for 2.75-in rocket's folding fin components. Manual production checks are performed throughout manufacture. Above: One of Zeebrugge's traditional defense products. Firm has long history of producing armor- and concrete-piercing rounds.

is delivered to the production complex by pipe. A vacuum mold is immersed in the charging tank for a specified period, forming a shaped, moist mat of the mixed fibers in the general dimensions of the die.

The mat is removed and placed over a similar mold in a press. Here much of the water is removed under mild heat and pressure and the mat emerges as a dense cylinder, easily handled and roughly in the shape of the final case dimensions. The finishing operations consist of resin impregnation, curing and final machining.

Work scope—Zeebrugge is about to install a large resin-impregnation and curing line in an area adjacent to the initial mat-forming units. Current development includes 90mm, 105mm consumable (France), 105mm howitzer and a case for the 105mm Russian guns used by Finland. All these have metal obdurators.

Zeebrugge is also developing a fully combustible cartridge case that will eliminate all metal components for the new German 120mm gun now in the early design stages. This gun will be designed specifically for combustible cartridge cases.

Besides the normal adaptations needed to convert any U.S. process to European production practices, the chemical compositions of the cases will be changed. Zeebrugge will use polyurethane resins instead of the more common epoxies used in the U.S. In addition, the gunpowder compositions evolving from the different military specifications pose some problems in case compatibility. These can be handled without difficulty, according to Zeebrugge experts.

Generation in munitions—Zeebrugge has produced ordnance products since 1932. The first plants were located in the North Sea town of Zeebrugge, hence the name. World War II effectively eliminated these works and the firm ceased its industrial activity from 1940 until 1947, when the current facilities were set up in Herstal.

The firm handled various projects in the early 1950's within the framework of the American offshore procurement policy. These orders involved production of all the metallic components for 60mm, 81mm, and 120mm mortar ordnance and shells for the 90mm and 105mm guns.

Zeebrugge quickly caught on to the coming shift to rockets and the firm's experts launched themselves into this new technology in 1954. Zeebrugge technical people and production specialists visited U.S. firms and various agreements were signed with U.S. firms and installations. These are constantly maintained.

This policy allowed Zeebrugge to land large production orders for the 2.25 sub-caliber air rocket (SCAR), 5-in. high-velocity air rocket (HVAR) and the 2.75 folding fin air rocket (FFAR) and meet delivery schedules for all NATO customers.

In addition, Zeebrugge has kept on top of developments. The firm has secured licenses from U.S. inventors for both the manufacture of the folding fin and the motor of the 2.75 rocket. Technical assistance of U.S. manufacturers has also been secured.

Zeebrugge has the manufacturing rights to the 5-in. *Zuni* FFAR rocket—the unguided complement to the more expensive guided missiles used by European navy and air forces.

Expansion—About four years ago, Zeebrugge moved into the manufacture of complete rounds—including the charging or loading operations.

To do this, the firm leased Fort Evegnee from the Belgian government—a complex of heavily reinforced underground magazines and corridors a short distance from Herstal. All live or explosive assembly is carried out in this fort—now known as works III.

With this facility, Zeebrugge has been completely assembling and loading 2.75 units and expects to handle the total *Zuni*—fabrication and loading.

The fort has a small rocket test stand to perform quality control checks on production lots of various rockets.

The involvement with air-to-ground armament led the firm quite naturally into production of the launchers for aircraft. Zeebrugge again has agreements with U.S. firms, in this case, Chromecraft, covering these assemblies. The family of launchers handled by Zeebrugge include the MA-2F, MA-3G, 7- and 19-tube cylindrical launchers covering five separate LAU types—both aluminum and rolled paper tubes.

The launchers use either the frangible, grenade-type fairings or machined aluminum alloy fairings. The frangible fairings fragment into pieces too small to damage the aircraft as the first 2.75 rocket bursts from the launcher. The aluminum alloy models have 7 or 19 openings, depending on the model, in a conical, aerodynamic shape. The rocket tubes are protected by polyurethane obdurators to prevent air entry during flight and eliminate the possibilty of premature ignition from heat caused by fast flight. These obdurators burst out with the launch of the rockets.

Depending on the model, these launchers can be set for single or ripple firings with patterns set by the user before production of the unit. Most of the launchers have a life of about 100 firings, which takes into account some minor maintenance at the aft ends.

All these launchers can be termed conventional, but Zeebrugge has perfected a new one designed specifically for a new VTOL tactical aircraft being

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Rapid expansion of space contracts, projects and studies at the HUGHES Aerospace Divisions in Southern California has created unusual opportunites for several qualified Engineers, Physicists and Mathematicians for Advanced Space Systems assignments.

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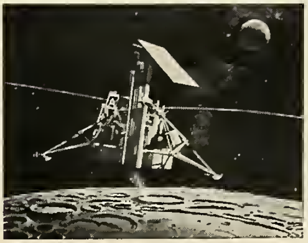

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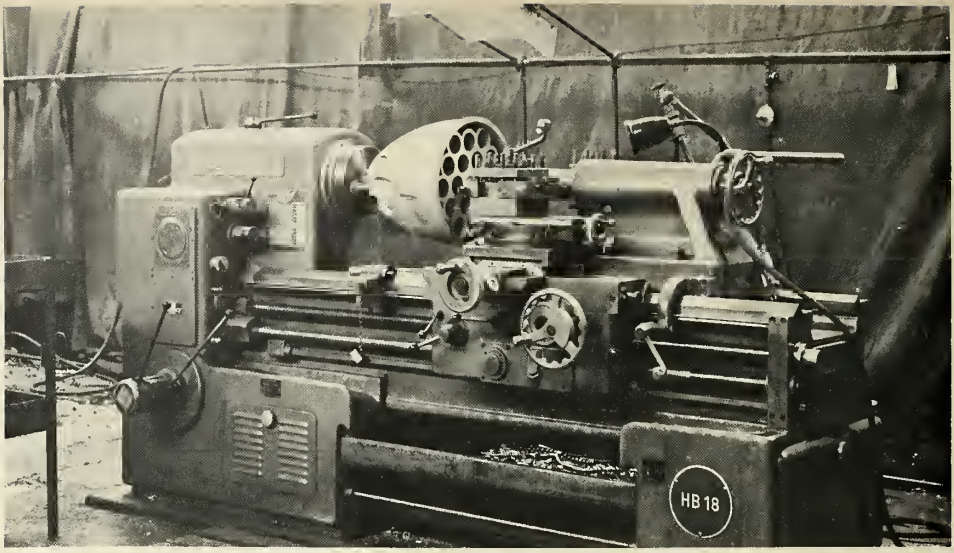


One of the 19-opening 2.75-in. rocket launcher aluminum alloy fairings is shown being machined at Zeebrugge.

developed by a German consortium. This design can be adapted to other fast-flying aircraft and helicopters. It is being built for the 2.75 rocket but can be adapted to fit the larger *Zuni*.

The launcher fits entirely inside the aircraft fuselage. Launcher tubes are essentially an endless belt, feeding loaded tubes in succession to the launch point. In operation, the lower end of the launcher emerges below the belly of the aircraft and only a single launching element protrudes at any one time. The pilot then fires the rockets singly or in ripple fashion. This design leaves the aerodynamic shape of the aircraft unencumbered except at the precise moment of firing. After the launching is completed, the unit retracts its single launch point. The VTOL version is now in prototype production at Zeebrugge.

Launchers are operationally tested with 2.75 rockets using dummy warheads routinely by firing the loaded launcher unit down one of the underground corridors at Fort Evegnee.

Zeebrugge is no longer producing *Sidewinder* tubes—its share of the NATO *Sidewinder* production effort. But the firm expects to be involved in any *Chaparral* production, should this weapon be adopted by NATO.

Launch tube effort—Zeebrugge has working agreements with U.S. firms for tube manufacture. Zeebrugge is now producing the new one-piece deep-drawn tube for the 2.75 rocket. The German military is evaluating the improved 2.75, and, if satisfied, will replace current stocks with the new 2.75 as they are used.

Zeebrugge will produce all the tubes and the linings for the *Redeye* when this weapon moves into the various NATO forces. The main delay is a combination of factors. Some of these are technical and cover *Redeye* performance. The major non-technical objection is a familiar one—European air forces dislike the idea of equipping their infantry with shoulder-fired weapons capable of reaching their own aircraft.

Redeye's command and control problem may well be the major obstacle to full adoption of the weapon by all NATO forces. Zeebrugge is not the only firm anxiously awaiting a decision.

Besides the obvious metalworking and plastics-fabrication ability demonstrated in the rocket and artillery ordnance work, Zeebrugge is a prime source for bomb fuses. Thousands of nose fuse M-904-E-2 units have been produced under license agreements with the U.S. In addition, Zeebrugge has designed delay fuses that render quantities of old, stockpiled bombs useful for today's high-speed aircraft.

One innovation delays the explosion of a bomb up to 12 seconds after impact, allowing plenty of time for a low-level aircraft to escape the explosion. The bomb problem arises from the fact that at high speeds the bomb will tend to follow the aircraft in a straight plane from point of launch. At low levels, where bomb impact could occur close to the actual line of flight, this could be somewhat dangerous.

The bomb fuses built at Zeebrugge all incorporate delay arming designs—up to 20 seconds in some instances. The fuse work at Zeebrugge involves a characteristic relationship with a subcontractor. Zeebrugge has developed a family of small outside contractors for precise and semi-precise machining, metal stamping, and even tension devices.

For instance, the highly precise bomb fuse subassemblies are made by Ets. Britte, S.A., in the Herstal-Liege area. Britte is well known to all European air lines. The Belgian shop provides the highly precise machine tool components necessary for jet engine repair, maintenance and conversions. Gages, gage blocks and accessories, machine tooling instruments, jigs and fixtures are all available on an engineering basis.

The fuse production sections at Britte are almost an extension of Zeebrugge. The same is true at A. A. Ateliers Stenne, a medium-precision metal-turning firm, and also at S.A. J. Renson, manufacturer of springs and tension devices. The close ties allow Zeebrugge to handle unforeseen production problems in a manner that would leave many U.S. production managers green with envy. The result is a complete grasp on complex tactical weapons production and scheduling.

The demands of NATO armament in the rocket fields call for production quantities and time schedules completely different from those in the U.S. For instance, Zeebrugge has made a total of more than 400,000 2.75 rockets since first acquiring the contracts. U.S. production in the current series, spawned by hostilities in Vietnam, is in the low millions. This weapon went out of production in the U.S. in the late 1950's.

Zeebrugge manager Depouhon claims that making working agreements with U.S. firms through the Belgian and U.S. governments saves both time and money, especially in defense procurements. But Depouhon is eager to take a crack at the commercial markets in Europe using the experience and production processes refined in ordnance and tactical rockets—and probably through more working agreements with U.S. firms. ■

Target System Aids German Training

Versatile Dornier application of Beech drone enables field practice in populous areas; recovery capability enhanced

LANGENARGEN/BODENSEE, GERMANY—A high-speed tow target system based on a completely mobile ground and flight complex is now being used to train West German combat elements in spite of the tight test-field restrictions existing in populous West Germany.

Developed by a department of Dornier System GmbH, the target system, with its vehicles, electronics, maintenance and command setup, is independent of any installation at a given training or other weapons test ranges.

The Dornier target vehicle is the Beech Model 1001 propeller-driven drone (KDB-1). All components and subsystems needed to assemble, fly, track, control and maintain have been adapted to wheeled vehicles.

In addition, the firm has developed a series of towed targets mated to the drone which virtually eliminates destruction of the drone in troop training.

The towed targets are also used with the Nord-Aviation CT-20 during French training operations.

Dornier experts use the Beech vehicle both as a target and as a flying test bed for various instruments developed by the systems group. There are no reconnaissance drone applications at the moment.

Economics involved—The towed target system evolved out of necessity. Money is extremely scarce in Germany for weapons development, testing and training. Thus, even the propeller-driven Beech vehicle is too expensive to be used primarily as a target. The result is the towed target and both vehicles are recoverable.

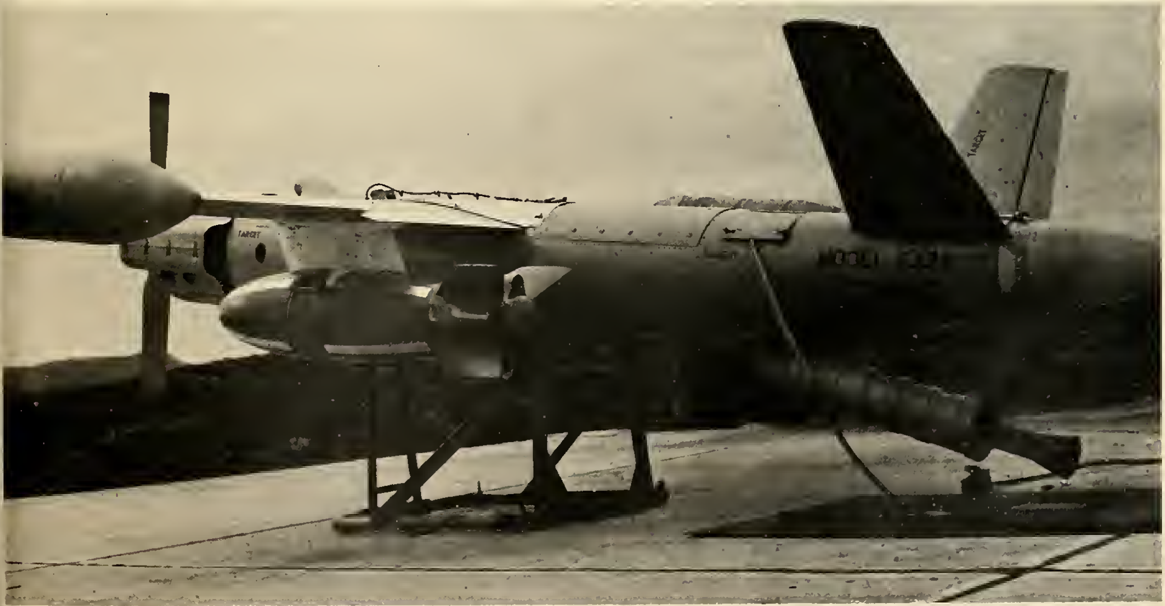
There are two towed targets in use —DS-SK-3 and DS-SK-4—differing essentially in size. The DS-SK-3 is about 47 in. long, 10 in. in diameter with a wing span of 16 in. The DS-SK-4 is approximately 57 in. long, 12 in. wide with a wing span of 19 in. Both are spin-stabilized and contain active electronics.

Both can carry Luneberg lenses—7 and 9 in. in diameter in the DS-SK-3 and 10 in. in diameter in the DS-SK-4—or corner reflectors and infrared flares. With infrared augmentation, the towed targets can be used to test the *Falcon*, *Firestreak*, *R-530* and *Sidewinder* air-to-air missiles.

Radar echo augmentation converts the target to such ground-to-air applications as training with *Bloodhound*, *Hawk*, *Nike-Hercules*, *Seacat*, *Talos*, *Tartar*, *Terrier*, *Thunderbird* and radar-guided guns.

Controlled towing—In operation, the towed target is attached to a wing pylon which is, in turn, affixed beneath the wing of the drone vehicle. The tow target is released prior to range presenta-

Dornier's tow target mounted beneath wing of Beech drone. Tow line drum is mounted in lower fuselage section and the line itself is taped along the fuselage across the wing to the target. The target is released by radio command.



tion by radio command. An automatic tow reel with an interchangeable piano-wire-loaded drum is built into the fuselage of the drone.

The cable runs from the drum to the towed target through a cable cutter. A centrifugal brake controls the speed of the drum and the rotating drum is automatically stopped when the cable is fully deployed.

If the target is not damaged or destroyed by a hit during the firing runs, the operator brings the drone in over the recovery area, releases the target which floats to Earth via parachute. The drone itself is returned to Earth in a second pass over the recovery area.

A direct hit on the target triggers the cable-cutting operation and jettisons the cable and towed target completely, allowing the undamaged drone to be recovered.

Dornier has a series of towing reel assemblies with differing tow-wire-length capacities up to 7,500 ft. One drum assembly is completely waterproof and designed for use over ocean target ranges.

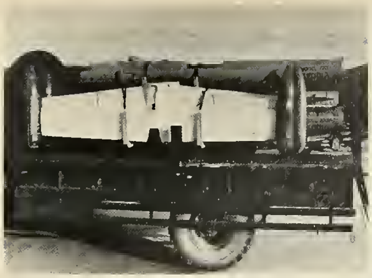
Target details—The towed units have been flown to speeds of Mach 0.92 and all are bomb-shaped glass-fiber reinforced polyester airframes. The present targets use an acoustical miss-distance measuring system but Dornier is perfecting a Doppler-based assembly for incorporation into the targets.

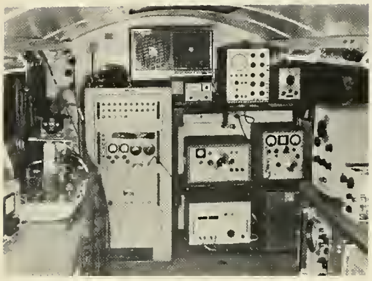
The targets have a good radar signature. Even the smaller unit shows up well on the screen when towed directly at the ground pickup. Troops in training can easily distinguish between the drone and the target on their radar sets and avoid nailing the relatively expensive towing vehicle in gunnery sessions.

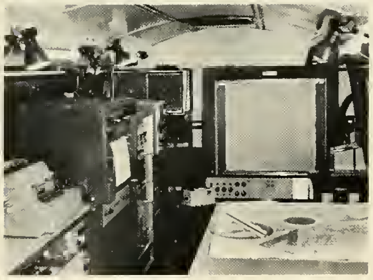
The department also has a manned aircraft tow target designated the DS-SK-2, complete with both infrared and radar augmentation and an optional parachute recovery system.

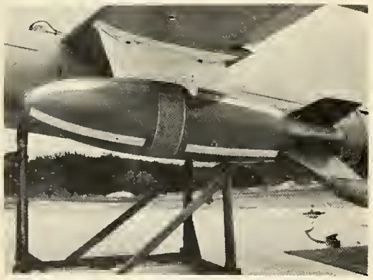
While the Langenargen works department of Dornier Systems is primarily concerned with the development and operation of target and other drones, the group is studying other concepts such as the Rogallo wing and flexed wing vehicles for cargo deliveries via helicopters. In addition, a small but efficient electronics section is perfecting a compact satellite transmitter for possible use in either European or German national space programs. The electronics section is responsible for the development of the Doppler miss-distance indicator system.

The tow targets have a critical top speed of Mach. 0.95. All towed targets have proven highly effective in range firings with both missile and artillery rounds. The economy of the system, together with the feasibility of 100% mobility, has been demonstrated. ■









Top left: Two Beech target drones packed for field transportation. Racks are also used as assembly and work stands at launch site. Above: Dornier mobile complex is a system of tents and trucks. Maintenance, electronics and assembly tents are in background. Drone is being assembled on its transport dolly. Left: One van is devoted entirely to electronic component test and checkout, together with minor repair and adjustment facilities. Second from bottom: A second van is actually a completely equipped control center for the firing flights and test-bed flights involving analysis of flight systems such as altimeters and other airborne components. Bottom left: Close-up of one of the tow targets. Silver bands are antennas. The acoustical miss-distance indicator is housed in center portion of target behind screen and baffle arrangement. Tubes appearing between fins hold flares if these are to be used in a flight. Target drones have been flown with Nord Aviation's CT-20 target vehicle. Target spins in flight and contains a parachute recovery system, which is triggered by any abrupt or gradual decrease in the towing pressure. Towing cable is severed by a cutter mounted next to towing drum in the drone's fuselage.

TOW SYSTEM COMPONENTS

Launcher (Pylon with Release Mechanism)
DS-SG-3—for attachment with Target DS-SK-3
Dimensions: Span—123 mm
Depth—560 mm
Profile—Symmetrical
Weight—3 kp

All parts salt-water resistant

DS-SG-4—for attachment with Target DS-SK-4
Dimensions: Span—123 mm
Depth—560 mm
Profile—Symmetrical
Weight—3.4 kp

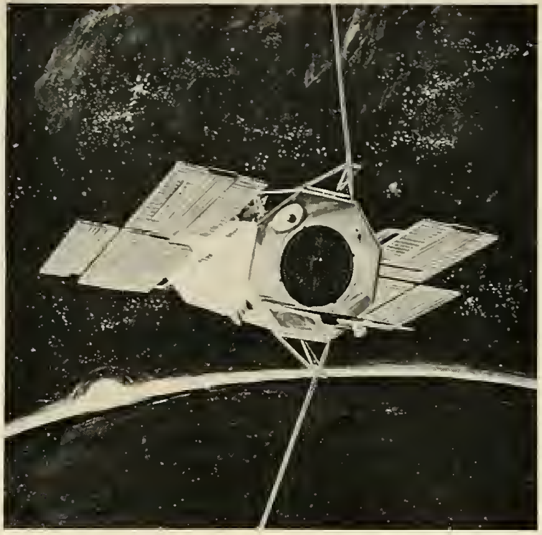
If the launcher is mounted on one wing, a compensating pylon DS-AP-3 or DS-AP-4 may be required on the other wing.

Towing Reel with Cable Cutter
DS-W-2—Capacity: 800 mm steel wire
0.8 mm dia.
Dimensions: Length—305 mm
Width—255 mm
Height—85 mm
Total weight—11.5 kp
Salt-water resistant

DS-W-3—Capacity: 2,500 mm steel wire
0.8 mm dia.
Dimensions: Length—315 mm
Width—320 mm
Height—150 mm
Total weight—27.5 kp
Air cooling—sea-recoverable

DS-W-4—Capacity: 1,500 mm steel wire
0.8 mm dia.
Dimensions: Length—305 mm
Width—290 mm
Height—115 mm
Total weight—22 kp
Watertight—sea-recoverable

this 22,000 part stabilization system



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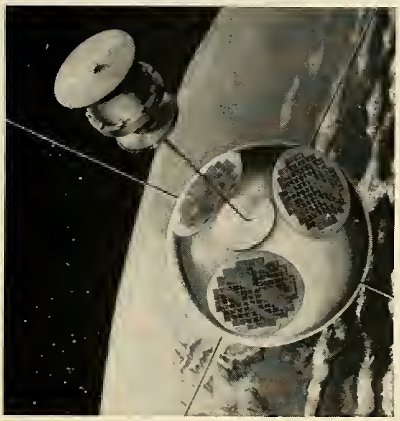

will have a lot hanging in the balance.

OAO and MAGS for example... with Nimbus, GGTS, and ATS somewhere in between. Which may give you some idea of how flexible our approach to space engineering is. To achieve the exceedingly accurate pointing requirements of the Orbiting Astronomical Observatory, we came up with a 22,000 part active control system which uses tiny rockets, gas jets, and thousands of electronic and mechanical parts to position the spacecraft and keep it there within one-tenth of a second of arc. Our Gravity Gradient Stabilization System, on the other hand, is a passive system with few moving parts and uses no power for operation, utilizing the earth's natural gravitational field to make a satellite constantly point to the earth to within two degrees of arc.

Our spacemanship is equally dexterous in other areas. SNAP-27 will be the first nuclear power system for operation on the surface of the moon. SPET (Solid Propellant Electric Thruster), with no valves, no moving parts, promises to be extremely valuable for increasing the reliability of active attitude control systems. In the important area of manned vehicles, we're working as a prime contractor on MOL. And we're studying a Voyager to go to Mars. Beyond that, we have ideas that haven't even reached the drawing boards yet.

If you have ideas on the subject, look into these opportunities: nuclear power, nuclear chemistry, thermionics, environmental control, IR/optics, simulation, human factors, life support, structures and weights, reliability, guidance & control, measurements and environments, materials development, spacecraft design.

Write in confidence to Mr. J. S. Barson, Dept. 394B-1, Valley Forge Space Technology Center, General Electric Co., P.O. Box 8555, Philadelphia, Pa.

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Saturn V Crawler Trouble Cleared Up

Successful load-carrying run on Jan. 28 seen removing huge vehicle from 'pacing' category; cost climbs by $5.1 million

by Sue Butler

CAPE KENNEDY—The crawler is not a pacing item for the *Saturn V's* initial launch on the *SA-501* mission, according to Kennedy Space Center Director Dr. Kurt Debus.

Lt. Col. Rocco Petrone, Debus's director of plans, programs and resources, echoed the statement Jan. 28 after the mammoth vehicle's first successful load-carrying run since its bearings failed last July 25.

At the same time, it was disclosed that costs for two crawlers ordered will exceed the original $9.1-million cost-plus-incentive-fee contract with Marion Power Shovel Co., Marion, Ohio, by $5.1 million—for a total price tag of $14.2 million.

Only half this sum is attributable to "overrun," KSC Procurement Director Michael Haworth hastened to interject.

More than $2-million worth of materials and labor have been consumed by modifications and design changes, such as improvements to the braking system by addition of disc brakes, which had nothing to do with the flaws found in the automatic load-leveling system and bearings.

The problem with the automatic leveling system that is to compensate automatically for loads up to 12 million lbs.—the combined weights of the launcher-transporter and an *Apollo-Saturn V* space vehicle—has plagued engineers virtually since the initial crawler's delivery Jan. 23, 1965 (M/R, May 10, p. 17).

The 16 hydraulic jacks that make up the unique leveling system were found to be faulty, causing corners to be ± 2 in. out of plane. Specifications called for the tipping moment of the fully assembled, 364-ft. *Saturn V-Apollo* and its launcher-transporter to be limited to a maximum list of ⅙ of a degree. The inaccuracy in the leveling system caused an electrical signal to cut off automatically, shutting down the leveling system.

Several of the bearings were crushed last July during a 7.9-million-lb. load test. The failures occurred in some of the track support roller bearings, which transmit the load from the crawler chassis to the treads. Steering stresses resulting from heavy side thrust action that affected the load distribution were blamed for the major mishap.

January test success—The 6-million-lb. crawler is 131 ft. long and 114 ft. wide, its height adjustable from 20 to 26 ft. After new propulsion tests Jan. 25-27, it moved Jan. 28 on its four double-tracked treads to launcher umbilical tower No. 1 (LUT), parked northwest of the Vehicle Assembly Building; it lifted the 447-ft.-tall LUT from its four anchor mounts and inched it over the 130-ft-wide resurfaced crawlerway into the VAB's bay no. 1. The ¾-mi. trip was made in about nine hours, moving at 0.2 mph. Maximum speed under load will be 1 mph. The LUT, still lacking 900,000 lbs. of components, weighed 10.6 million lbs.

The new sleeve bearings held up well but no attempt was made to use the automatic leveling system. Instead, a redundant manual leveling mode, incorporated in the original design for use in the event of a power failure or component malfunction, was employed.

However, Petrone revealed the cause of the failure in the automatic leveling system, built for Marion by American Machine & Foundry, York, Pa., has finally been pinpointed. The problem was in the servo mechanism and resulted in "oversteering."

"The amplification of 1/2000th (in the circuitry) was too sensitive, cut out and shut down when there was no need for it," Petrone said. "It had been overdesigned."

General Electric's *Apollo* support department is now making analog computer runs to determine the precise gain needed. An exchange of filters is expected to correct the problem when the studies are completed, within two or three months.

Solution in sight—The problem is thoroughly understood, Petrone stressed, and a "fix" is now possible based on a mathematical model; however, "hardware may be different," he said. Computer time is expected to cost about $40,000.

The steering problem, closely linked with the automatic load-leveling system, has been under study for some time by the Bechtel Corp. (Bechtel was assigned responsibility for work previously performed by AMF and had taken over installation of the hydraulic piping and modifications to the steering system.) Bendix will operate the two crawlers and is supervising the engineering on the hydraulic system.

The manual leveling mode consists largely of four mercury-filled monometers, one in each of the platform's four corners, plus two monometers near the middle of the platform.

Although two operators are preferred, one operator can control the manual leveling system by means of a "ticklebox" and three joy sticks—two of which control the level across the two sets of diagonal corners, with the third needed for equalization.

The crawler's bearing difficulties appear to be solved with replacement of 176 anti-friction steel rollers by "Bearium B-10" sleeve and thrust bearings.

Original design wrong—Debus emphasized that the original bearings were not faulty but were undersized and not designed for unpredictably large pressures. They had been designed to carry an unloaded weight of 3,000 lbs./ft.^{2} and 9,000 lbs/ft.^{2} when the crawler carried the mobile launcher and the *Saturn V-Apollo*.

Major components of the crawler had been tested, many of them to destruction, at the Army Corps of Engineers' Waterways Experiment Station a Vicksburg, Miss., and at the Southwest Research Institute in San Antonio, Tex Cylinders were tested by AMF. However, Debus said, it was virtually impossible to simulate the large weight without costly and time-consuming full scale models.

While the *Saturn V* crawler is essentially a modified version of heavy crawlers developed for strip mining operations, the coefficient of friction in model tests at the Southwest Institute for a 28-million-lb. stripping shovel built by Marion and an 18-million-lb. shovel built by Bucyrus-Erie was found to be only 0.3.

The coefficient of friction for the *Saturn V* crawler was estimated at 0.4; the vehicle was designed to 0.6. However, the run last summer showed a coefficient of slightly over 1.0, far greater than anticipated, Debus explained.

Installation of the Bearium B-10 sleeve bearings with three times the load-carrying capability of the steel rollers was the outcome of an unavoidable "trial and error" method, he said.

"The crawler is a development job—we're not buying a car off the line," Debus said. Many now-known facets of technology, such as sloshing, "are in no engineering handbook," and there are still many "unknowns," particularly in the area of friction, he noted.

New bearing specs—The new sleeve bearings consist of 70% copper, 10% tin and 20% lead. The leaded copper was produced by the Bearium Metal Products Co., Rochester, N.Y., under contract to American Crucible, Lorain, Ohio.

Revelation of the subcontract with American Crucible came as a surprise; originally, it had been expected Torrington would supply new bearings of different design.

The Bearium bearings, instrumented to 100°F but said to tolerate heat up to 150° or even 200°F, are 1-ft. long, have an inner diameter of 11¾ in. and an outer diameter of 13¼ in. The companion thrust bearings are 1-in. thick, have a 5-in. ID and a 13½-in. OD.

Steel shaft adapters have been added to bring the sleeve bearing ID to 11¾ in. This increases bearing area, reducing pressure on the shaft, Petrone said.

After boring out the 11 holes damaged by crushed roller bearings last July, new shafts were installed throughout. Existing 3-ft.-long shafts were replaced by units 4 ft. long to increase bearing surface. Other new hardware included thrust adapter plates and bearing end caps.

Experimentation with different lubricants indicated no change was necessary. Grease is squirted between adapter and bearing, where the rotation takes place, at intervals of about two minutes.

Petrone said normal average bearing operating pressure in the straightaway will be 750 psi and 3,000 psi on the crawlerway's curves. For leeway, each bearing has been designed to a maximum of 3,100 psi; Four out of every 11 are said to be capable of supporting the entire load.

During the weight-carrying test last July with mobile LUT No. 3, the psi rate was as high as 3,300, but the crawler was then running on a fairly stable 2-in. surface of river rock and lime aggregate, according to the NASA official. Problems were further compounded by the fact that treads picked up some of the macadam coating of the roadbed.

Roadbed built up—Improvements in the composition of the crawlerway surface to facilitate steering include addition of 16.9 million lbs. of river rock. The 7-ft.-deep crawlerway, consisting of 90% compaction of hydraulic fill and decayed coquina shell, has been topped by a layer of river rock 4 in. high on the straightaway and built up to 8 in. on the bends. This sliding surface reduces friction on the turns, Petrone said. After each crawler trip, the runway's surface will be swept and leveled "like a racetrack," he added.

The crawlerway improvements, totaling $1 million not included in the $14.2 million direct-cost figure for the crawlers, also include increasing the turn radius on the curves from 500 to 600 ft., a further aid in steering.

No change has been made or is advocated in the five-degree incline to the launch pad ramp which the crawler will have to negotiate while keeping its load within 1/6th of a degree of true vertical.

LUT No. 1, carried in the crawler's most recent test, will be the one used for *Saturn 501*, the first flight bird, after checkout with all three facilities stages, an instrument unit (IU-F) and a dummy *Apollo* spacecraft. The S-IC-F is already here, delivered by Boeing, June 19.

Additional launchers ready—Two other mobile launchers are standing by, including LUT No. 3, which is incomplete and weighs only 7.9 million lbs. No. 3 made the initial trip atop the crawler last summer and is now scheduled to be moved to launch pad 39A for preliminary pad checks in about three months.

LUT No. 1, now in the VAB, is undergoing interface work in the cell. The basic computer system is already installed, but approximately 900,000 lbs. of additional electrical support equipment (ESE) and ground support equipment (GSE), including the 500,000-lb. swing arms, are to be added in the VAB, bringing the total weight of the mobile launcher to 11.5 million lbs.

The launcher will remain in the VAB until late May or early June. The crawler will then return, moving unloaded at a maximum speed of 2 mph, pick up the LUT and assembled facilities vehicle (500F), and move both 3½ mi. to pad 39A for checkout. They will be returned to the VAB in September or October, according to present plans. ■

collage

More Motorola mishmash, continued from page 11

To Hell With Pavlov

As any fool knows, the triggering mechanism of the Venus Fly Trap plant is activated only when one or more of its six hair-like antenna things are titillated at least twice. So this week's class project is to keep sneaking up on one of the carnivorous beasties and agitate an antenna just *once* each time. Before long it'll become psychotic . . . snapping at passing Yamahas or just saying to hell with it and going vegetarian.

Sic Transit Gloria Murphy

Our Western Center's Earl (not Gloria) Murphy is driving a few *people* mad by cross-breeding both hardware and language. He mated an antenna with an amplifier to produce an "antennafier"; an "antennamitter" resulted from some hanky-panky between an antenna and a transmitter.

A NOBEL PRIZE
(or something)
FOR GROVER

Can anyone use a couple hundred feet of coaxial cable that have been cunningly reduced to the dimensions of a .6 x .6 x .187 in. flat-pack? Well, that's what our Western Center's Grover Kennett has come up with using a few tricks like thin film capacitors, and he claims the delay time is comparable. Now if we can find a customer Grover will be recommended for the Nobel prize. If not, his resumé is available upon request.
For more information, write to our Western Center.

Continued on page 42

Circle No. 3 on Subscriber Service Card

Test Engineering Openings at Boeing Atlantic Test Center

The Boeing Company's deep involvement in the nation's most important missile and space programs is providing qualified engineers and scientists career opportunities of unusual scope and growth potential. Boeing currently is weapon system integrator for the U.S. Air Force advanced Minuteman II ICBM, prime contractor for the National Aeronautics and Space Administration Lunar Orbiter moon-scanning satellite, and a major contractor on the NASA Saturn V launch vehicle.

A number of highly interesting and challenging assignments are available at the Boeing Atlantic Test Center at Cape Kennedy for candidates experienced in the fields listed in the column to the right.

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liquid propellant, hydraulic, pneumatic, environmental, umbilical, and water systems

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AIRBORNE/GROUND TELEMETRY AND INSTRUMENTATION ENGINEERING

SYSTEMS ENGINEERING

ENGINEERING SYSTEMS ANALYSIS

INDUSTRIAL ENGINEERING/PERT
Analyst for program management and Site Activation Board support

LOGISTICS AND MAINTENANCE ENGINEERING

Above openings require a B. S. degree or higher in an engineering discipline. Applicable work experience is required.

Additional openings are available for:

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Send your resume, today, to Mr. L. S. Bonsteel, Boeing Atlantic Test Center, P. O. Box 1698-MTR, Cocoa Beach, Fla.

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Also, Boeing Scientific Research Laboratories

The Industry Week

Mergers and Acquisitions

Lear Siegler, Inc., Santa Monica, Calif., has purchased all assets of C. G. Hokanson Co., Inc., for an undisclosed amount of preferred and common stock. Hokanson is a Los Angeles manufacturer of missile systems ground-support air-conditioning equipment. Lear has also completed acquisition of Mammoth Industries, Inc., Minneapolis. Mammoth also produces air-conditioning equipment. . . . *General Dynamics, New York City, has announced plans to acquire Dynatronics, Inc., Orlando, Fla., with shares of GD common stock. Dynatronics produces advanced telemetry equipment and will become a separate operation within GD's Electronics Div.* . . . Northrop Corp., Beverly Hills, Calif., is considering purchase of The Hallicrafters Co., Chicago. Terms of the transaction are under negotiation, but total purchase price will probably be approximately $20 million, a Northrop spokesman said. . . . *Honeywell, Inc., Minneapolis, plans to buy the assets of Electro Instruments, Inc., San Diego, Calif. Purchase price will be approximately 75,000 shares of Honeywell stock. The agreement is subject to final approval of the boards of both firms.* . . . Bendix Corp., Detroit, has acquired the assets of Fonda Gage Co., Inc., Stamford, Conn. The company will be operated as the Fonda Div. of The Sheffield Corp., Dayton, Ohio, a Bendix subsidiary. . . . *Computer Sciences Corp., El Segundo, Calif., has agreed to acquire the outstanding stock of Geonautics, Inc., Washington, D.C. Geonautics provides services in the fields of geodesy, oceanography, navigational systems and astronomy.* . . . Philco Corp., Philadelphia, has purchased General Micro-electronics, Inc., Santa Clara, Calf., from the Pyle-National Co., Chicago, for approximately $4,350,000.

International

Fairchild Controls, Hicksville, N.Y., division of Fairchild Camera and Instrument Corp., has named Controls Instrument Co. GmbH, Munich, West Germany, technical distributor for all division products in Germany. . . . *General Precision, Inc., Tarrytown, N.Y., has expanded its licensing agreement with Toko, Inc., Tokyo, Japan, to include manufacture and sale of Toko's plated-wire computer memory for commercial applications in the U.S.*

New Activities

Bendix Corp., Detroit, has consolidated its activities at the Kennedy Space Center into a new Launch Support Div. Frank W. Vaughn will act as general manager of the division. . . . *Consolidated Electrodynamics Corp., Pasadena, Calif., has established a corporate product and market development group. Eugene J. Moscaret, CEC vice president, will be in charge of the group. Function will be to initiate product developments for markets new to CEC.* . . . Seifert X-Ray Corp. has been formed in King of Prussia, Pa., to sell and service Seifert X-ray equipment in the U.S. President of the firm is Richard Seifert, owner of Rich. Seifert & Co., Hamburg, Germany.

Facility Expansions

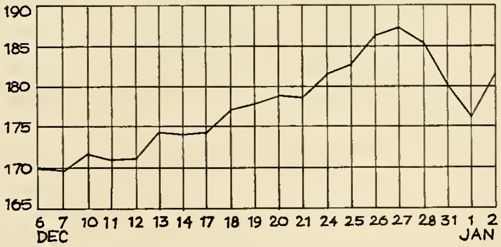
Radio Corp. of America, New York City, plans to spend a record $195 million in 1966 on plants and equipment. The expansion will create more than 15,000 new jobs, a company spokesman said. New plants are scheduled to be built in Memphis, Tenn., Indianapolis, Ind., and Lewiston, Me. . . . *Gardner Cryogenics Corp., Hightstown, N.J., and Alamo Chemical Co. plan to construct a jointly owned helium extraction and liquefaction plant near Elkhart, Kan.*

Potpourri

Stockholders of LTV Aerospace Corp., Dallas, will meet Feb. 8 to vote on three actions affecting the company's common stock. The actions, recommended by LTV's board of directors, include: 1) a 2½-for-one stock split; 2) adoption of an $0.80 annual cash dividend policy for each share of publicly held common stock after the split; and 3) a reclassification of the common shares held by LTV into a new non-dividend Class B common stock. . . . *HITCO, Gardena, Calif., has filed a patent infringement suit in Los Angeles District Court against J. P. Stevens & Co., New York City, John S. Frey Co., Los Angeles, and two individuals. The suit involves a patented process for producing high-purity silica, marketed by HITCO under the trademark, Refrasil.*

Missile/Space Stock Index

Wall Street analysts were unable to attribute the sudden drop in defense stock prices Jan. 31 to any one factor except a moderate amount of profit-taking. While some had expected stocks to rise with the announced resumption of bombing and renewed intensification of the war in Vietnam, others point out that this move had been expected and had already contributed to a sensational rise in aerospace/defense stocks the week before. Also of interest: Boeing's board of directors meeting Jan. 31 did not produce a split announcement, thus postponing chance for such a move for another three months or so.



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

MSC Gets Advanced Docking Simulator

Prime for high-resolution system is F. B. MacLaren; Dage-Bell Corp. supplied closed-circuit TV; Photomechanisms, Scanoptic are other subs

A HIGH-RESOLUTION computer-driven simulator for studies of human engineering problems encountered when docking spacecraft during the last 500 ft. of rendezvous has been delivered to the Manned Spacecraft Center.

The system uses one-fiftieth scale models viewed by a closed-circuit television system. Investigations will be carried out on the optimum location and sensitivity of an astronaut's maneuvering controls. Feasibility of various docking procedures will also be studied.

Particular attention will be given to the problems of Lunar Excursion Module (LEM) docking maneuvers in the *Apollo* program.

Models to be used will include the LEM *Apollo* Command and Service Modules and an *Agena D*. These can each be viewed against realistic backgrounds and under many conditions of solar illumination. Some thought is being given to using the computer system for lunar landing simulation.

The pilot sees the rendezvous situation on a high-resolution television monitor, viewed through a virtual image projection system. The projection system shows the televized scene as if through a window, with no image motion as the pilot moves his head.

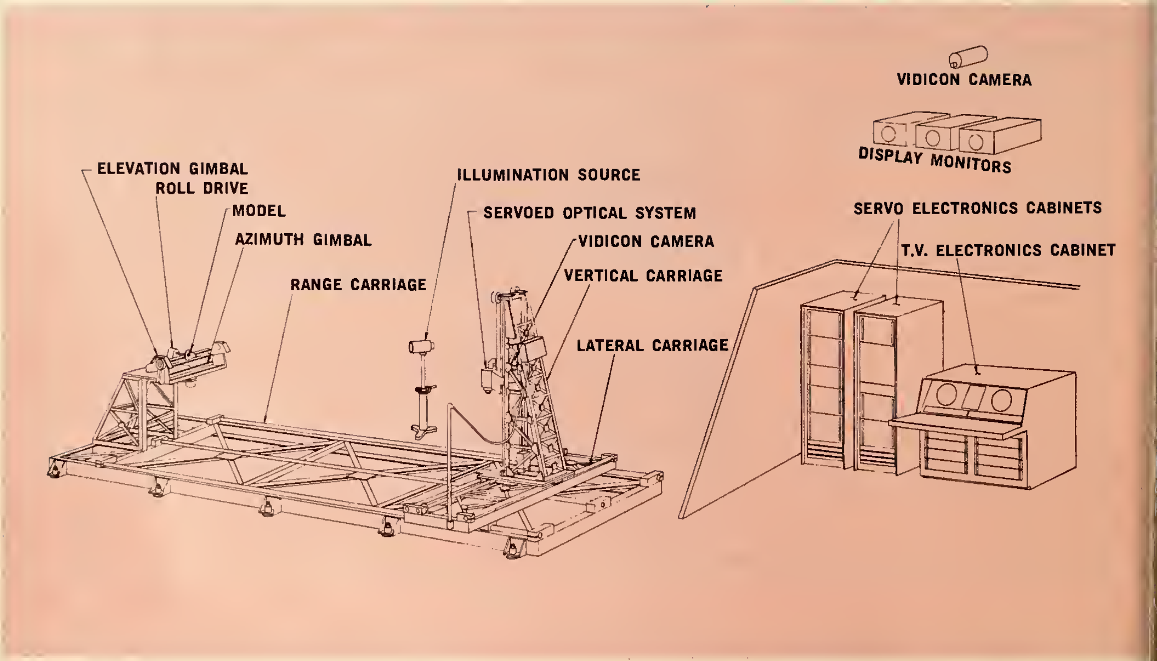
Motion effects—A vidicon camera views a model of the target spacecraft. Motion effects are simulated by servomechanisms that drive both camera and model in relation to a common framework. The loop between the pilot and model and camera control system is closed by an electronic computer. It takes signals from the pilot's control movements and converts them into servo drives to produce the corresponding image motion.

The model can be rolled through ± 25 degrees in three axes to simulate attitude control maneuvers of the target. The vidicon camera can be translated in three axes, simulating the translational movements of the pilot's spacecraft. Simulation of attitude control motions of this spacecraft is achieved by movement of prisms in an optical scanner in front of the television camera.

By this means, the simulated vehicle and target can duplicate virtually all the motions of their real counterparts as they undergo various forms of maneuver. As the system has a fly-by capability, a missed docking can be simulated when the pilot passes the target.

To achieve realism, care is taken to produce models with antennas, thrus-

Line drawing of simulator shows carriage that transports optical scanner and TV camera along outside tracks, with motion imparted by lead screw in center. Illumination source is narrow beam lamp that simulates the Sun.



tors, tanks and markings precisely represented. All supporting mechanisms have non-reflective black coatings, which, coupled with threshold gating of the video signal, assure that only the model appears on the television monitor.

An electronic gating device operates when a second camera provides a background, to key out the background over the target image. At a separate console, an operator can control the television system performance while viewing the results on 17-in. monitors.

Prime contractor for the simulator was F. B. MacLaren and Co. The unit is installed in MSC's hybrid computation and simulation branch. The assembled track and carriage measures 16 ft. long, 6 ft. wide, and 9 ft. high, and weighs about 600 lbs.

Stiffness required—A chief requirement of the structure is high stiffness to avoid vibration appearing on the scene on the monitors when the system components move. A carriage-mounted framework holds the scanner and camera and transports them toward the model on ball bushings along a precision track. Driving motion is imparted by a ball-bearing lead screw. Similar drives are used for vertical and horizontal movements.

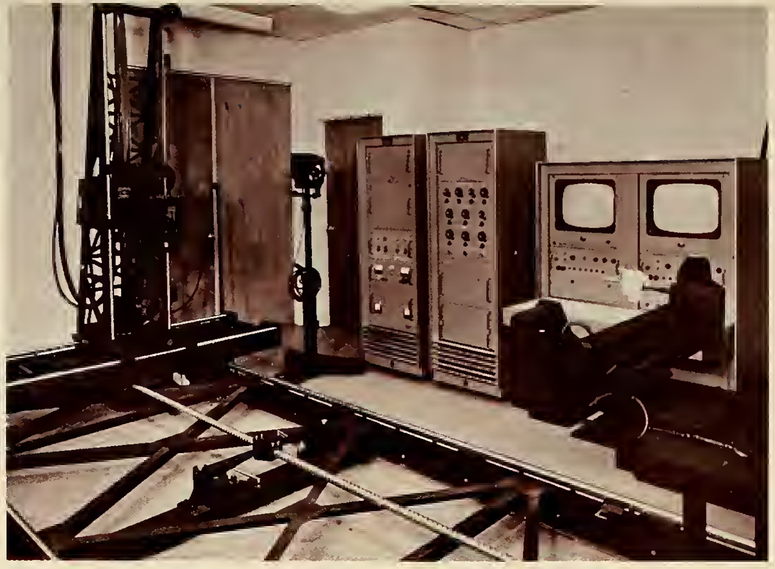
Smoothness in the servos is achieved by exact alignment of high-accuracy gear trains. In this system, gear trains with ratios as high as 2,000:1 can readily be turned backward, compared with the more usual limit of 300:1. Drives, structures and models were supplied by Photomechanisms, Inc.

Dage-Bell Corp. supplied the closed-circuit television system, which makes use of two Series 1428 high-resolution vidicon systems. One views the model; the other views a simulated horizon, Moon background or star field. Both channels have 1,029-line horizontal resolution and have 21-in. monitors.

Within the optical scanner supplied by Scanoptic, Inc., is a scanning prism driven by the elevation servo. The azimuth servo drives a fixed prism, an objective lens and two rhomb prisms. The roll servo drives a delta prism. Other components in the scanner are a focusing lens, translated by a focus servo, a correction lens, a manually adjustable iris diaphram, and an imagings lens for the vidicon faceplate.

Entrance pupil of the optical scanner is very close to the front surface of the small scanning prism, enabling the unit to approach within a fraction of an inch of the model—a simulated distance of a few feet.

Instantaneous freeze of all servos can be achieved with a panic button if damage to the opticals and drive threatens. The same action is activated by capacitance proximity probes on the scanner. ■



Photograph of space docking simulator detailed in drawing on opposite page. The mechanism that supports the spacecraft model is shown in right foreground.

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space electronics

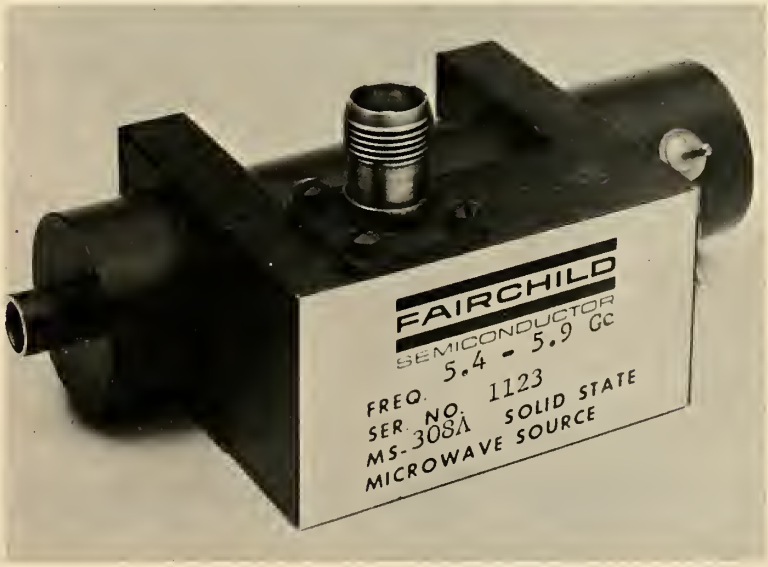
New Product of the Week:

C-Band Signal Sources

Two solid-state C-band microwave signal sources which provide a minimum of 5-mw power output over specified tuning ranges have been announced by Fairchild Semiconductor.

Models MS306A and MS308A offer low residual FM noise, less than 2 cycles RMS. MS306A is single-screw tunable over a 4.4 to 5.0-gc range. MS308A is single-screw tunable over a range of 5.4 to 5.9 gc. Both can be voltage-tuned.

The sources are rated for operation from —55° to 100°C. Spurious har-



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monics are at least 60 db below output within specified tuning ranges and 50 db below output outside specified tuning ranges, the firm says. Both sources offer solid-state reliability.

Circle No. 151 on Subscriber Service Card

Temperature Controller

Cryotronics, Inc., is marketing a proportional temperature controller with a range of 4.2° to 300°K.

The Cryodial unit provides a control accuracy of ±20 millidegrees when used in conjunction with a heater-sensor and refrigeration system. Typical sensors used are carbon and platinum resistors, germanium diode thermometers, thermistors and transducers.

The standard heater and temperature sensor assembly is a 40-watt zener diode and a platinum resistor.

Circle No. 152 on Subscriber Service Card

High-Frequency Recorder

Genisco Systems Div. is marketing a high-frequency recording system for data recording under field conditions.

The system provides frequency response from dc to 600 kc, or pulse response to 500 nanosecs. rise time. No bias requirements or critical record levels are needed. The recording uses a high-frequency FM record amplifier and a reproduce amplifier and discriminator. A flutter compensation module is available.

System response is flat ±1.5 db, from dc to 600 kc, at 120 ips. S/N ratio is 35 db. Pulse response gives less than 5% overshoot at minimum response time.

Circle No. 153 on Subscriber Service Card

Backward-Wave Oscillator

A magnetically shielded PM-focused backward-wave oscillator, measuring 2 x 2 x 6 in. and weighing under 2 lbs., has been announced by Watkins-Johnson Co.

The Model WJ-2004 exceeds environmental requirements of MIL-E-5400, Class II. It is permanent-magnet focused and requires no forced air cooling. Frequency range is 9.5 to 13.0 GH with a minimum power output of 10 mw. Power input is under 5 watts, including heater.

Circle No. 154 on Subscriber Service Card

Megabit Memory System

A half-microsec. megabit memory system with a demonstrated cycle time of less than 500 nanosecs. has been introduced by Electronic Memories, Inc.

The Nanomemory 500 has a capacity of 16,384 words of up to 84 bits. It uses 2½-D selection techniques and an 18-mil. core. Other specifications include an access time of 250 nanosecs. and input of 115v ac, ±10v ac, 60 cps. Operating environment is 10 to 40°C ambient and up to 90% relative humidity without condensation. Modes of operation are clear/write, read/restore and read-modify—write (split cycle).

Circle No. 155 on Subscriber Service Card

Voltage-Tunable Magnetron

A line of magnetically-shielded voltage-tunable magnetrons has been introduced by EIMAC Div. of Varian Associates.

The tubes are shielded against degaussing effects of other permanent-magnet devices, dynamic magnetic fields, and stray magnetic radiation. Circuit design allows the tubes to contact other ferromagnetic materials or components without degrading performance.

The line is intended for use in radar receivers, telemetry systems, and electronic units subject to rigid high-density packaging limitations. Tubes cover the 50-mw to 75-watt power range at frequencies from 250 to 3,200 mc.

Circle No. 156 on Subscriber Service Card

A/D Converter

Capability of transmitting analog data in high-speed digital form directly from missiles and spacecraft is offered by the Series 514 analog-to-digital converter developed by RC-95, Inc.

The unit measures 2½ x 2½ x 3¼ in. and weighs less than 1 lb. It meets requirements of MIL-E-5400, with up to full 14-bit accuracy. Size and weight reduction was made possible by the use of monolithic integrated circuits. The unit accepts analog voltages in the 5-v range or higher if required. Series and parallel outputs are available simultaneously. The unit has multiple ranging options and has a quoted stability of ± 0.005% per year.

Circle No. 157 on Subscriber Service Card

Tunnel Diode Amplifier

A compact, lightweight tunnel diode amplifier has been developed by Micro State Electronics Corp., subsidiary of Raytheon Co.

Model NC-5607 measures 6 x 3 x 1 in. It operates between 5.4 and 5.9 gigacycles in the X-band with gain of 15 db and noise figure of 5 db.

Circle No. 158 on Subscriber Service Card

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Seven X-acto blades and one X-acto handle give you seven surgically-sharp, precision X-acto tools just made to order for countless jobs in the shop, stockroom, factory and office.

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collage

More Motorola mishmash, continued from page 35

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contracts

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$3,921,424—**Columbia University,** New York City, for Project Defender studies.

$3,000,000—**Philco Corp.,** Palo Alto, Calif., for continued work on a satellite-control network.

$2,000,000—**Bell Aerospace Corp.,** Buffalo, N.Y., increment to a previously issued contract for procurement of rocket engines.

$95,794—**Rocket Research Corp.,** Seattle, Wash., for development of low-temperature gas generator technology.

$94,000—**United Technology Center,** Sunnyvale, Calif., for survey of flame characteristics of a variety of rocket propellant compositions to determine infrared output.

$93,723—**California Institute of Technology,** Pasadena, Calif., for research on high-resolution spectroscopy of small molecules in the gaseous state.

$72,359—**Sperry Rand Corp.,** Ford Instrument Co., Long Island City, N.Y., for study of weapons effectiveness assessment concepts.

$66,162—**University of Tennessee,** Space Institute, Tullahoma, Tenn., for study of thrust vector control by electric arc discharge.

$51,500—**Space Sciences Laboratories,** Beverly Hills, Calif., for study of high-energy solid fuels.

$44,926—**Atlantic Research Corp.,** Alexandria, Va., for research on hydrogen-fluorine.

$25,666—**Avco Everett Research Laboratory,** Everett, Mass., one-year contract to study how the fluid dynamics of blood affects clotting.

ARMY

$5,200,000—**Philco Corp.,** Philadelphia, first segment of an $8-million contract for research and development work in support of the *Chaparral* air-defense missile project in Newport Beach, Calif.

$3,310,501—**Philco Corp.,** Newport Beach, Calif., for continuation and implementation of R&D services to adapt *Shillelagh* to the main battle tank. Also, $490,000 for FY 1966 *Shillelagh* missile system research, development, test and evaluation program. Also, $108,699 for technical publications for *Shillelagh* system.

$852,165—**Northrop Corp.,** Northrop Space Labs, Hawthorne, Calif., for *Nike-X* technical services for 12 months.

$666,125—**Alcan Aluminum Corp.,** Riverside, Calif., for metal parts for M54 rocket motor.

$220,955—**Raytheon Co.,** Andover, Mass., for *Hawk* missile system repair parts.

$93,939—**System Development Corp.,** Santa Monica, Calif., for development of procedures needed for integration of human factors elements into design of new Army system.

$80,000—**General Precision, Inc.,** Kearfott Div., Little Falls, N.J., for development of a two-degree-of-freedom gyro with pneumatic pickoff.

$71,690—**Astro-Space Laboratories,** Huntsville, Ala., for services and fabrication of inertial components and test devices.

$50,000—**Ryan Aeronautical Co.,** San Diego, Calif., for engineering services for the *Firebee* target missile.

NAVY

$20,000,000—**General Dynamics,** Quincy, Mass., supplement to contract now worth $86,950,000 to install satellite communications systems aboard ships being converted for NASA *Apollo* communications. Supplement covers electronic equipment.

$15,723,300—**Sanders Associates, Inc.,** Nashua, N.H., to produce electronics equipment.

$12,805,403—**Martin Marietta Corp.,** Orlando, Fla., for production of *Walleye* guided missile and related equipment.

$929,557—**G. W. Galloway Co.,** Baldwin Park, Calif., for guided missile Mk 51, mod O warhead metal parts.

$238,224—**Midway Co.,** Lodi, N.J., for Mk 48 mod O guided missile warhead.

$148,265—**Interstate Electronics Corp.,** Anaheim, Calif., for replacement parts for *Polaris* portable shipboard equipment.

$45,472—**Aracon Geophysics Co.,** Concord, Mass., for study on simulation of oceanographic and geophysical space-sensor displays.

$30,000—**Computer Applications,** New York City, to develop and structure an availability model for conformal array sonar system.

NASA

$897,000—**Lockheed Aircraft Corp.,** Lockheed Missiles and Space Co., Sunnyvale, Calif., from Marshall Space Flight Center for study of mission modes and systems analysis for lunar exploration.

$524,000—**TRW, Inc.,** Systems Group, Redondo Beach, Calif., from Lewis Research Center for guidance equation support, NASA/*Agena* mission.

$360,670—**ITT Federal Laboratories,** Nutley, N.J., from Goddard Space Flight Center for TDM communications applicable to medium-altitude satellites, design system fabrication and tests with *Relay* satellite.

$249,470—**Thiokol Chemical Corp.,** Reaction Motors Div., Denville, N.J., from Manned Spacecraft Center to engineer, fabricate and install shutter valves in altitude simulator system. Also, $221,377 to furnish bypass systems and steam modules in altitude simulator system.

$149,855—**TRW, Inc.,** Systems Group, Redondo Beach, Calif., from Western Operations Office for valve technology study.

$86,800—**Electro-Mechanical Research, Inc.,** Princeton, N.J., from Goddard Space Flight Center for image dissector sensor.

$74,817—**Ridge Instruments Co.,** Huntsville, Ala., from Marshall Space Flight Center for pressure calibration systems.

$64,356—**New Mexico State University,** University Park, N.M., from Goddard Space Flight Center for *Nimbus B* antenna pattern measurements.

$61,904—**Reynolds Metals Co.,** Product Development Div., Richmond, Va., from Marshall Space Flight Center, for R&D in application of white anodize to aluminum alloy surfaces.

$51,950—**Hydronautics, Inc.,** Laurel, Md., from Lewis Research Center for research on cavitation damage in high-temperature liquid alkali metals.

$49,997—**Unified Science Associates, Inc.,** Pasadena, Calif., from Western Operations Office for study of gaseous electrolytes for batteries and fuel cells.

$45,531—**United Aircraft Corp.,** Corporate Systems Center, Farmington, Conn., from Electronics Research Center for research on critical computational problems concerning strap-down inertial navigation systems.

$41,757—**Bendix Corp.,** Baltimore, Md., from Goddard Space Flight Center for circular flight path system.

$29,940—**General Precision, Inc.,** Aerospace Group, Little Falls, N.J., from Electronics Research Center for a gas-bearing materials research study.

$21,250—**International Business Machines Corp.,** Federal Systems Div., Bethesda, Md., from Electronics Research Center for automatic symbol processing techniques.

INDUSTRY

$24,000,000—**Sperry Rand Corp.,** New York City, from **Bell Telephone Laboratories,** New York City, subcontract for work on the Army's *Nike-X* missile defense system.

COMMUNICATIONS SATELLITE CORPORATION

$60,000—**Centre National D'Etudes Des Telecommunication,** France, for research in regard to a medium-altitude satellite system.

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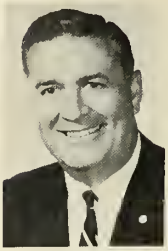

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Richard S. Farr: Named to the board of directors of the Genisco Technology Corp. He is president of the Farr Co.

Robert L. Alvarez: Appointed marketing manager for Europe, the United Kingdom, Scandinavia and the Near East for Fairchild Instrumentation, a division of Fairchild Camera and Instrument Corp. He will assume direct control for all of the division's marketing activities in these areas.

Maurice Gertel: Named vice president and general manager of the Aradyn Div. of Allied Research Associates, Inc. He presently serves as a graduate school lecturer in mechanical engineering at Northeastern University, where he teaches special courses on shock, vibration, and noise control.

Fred Zusman: Named director of the corporate computing center of Operations Research, Inc. He came to ORI in 1963 from the International Biomedical Research Foundation, where he was director of the computing laboratory.

Marvin R. Gore: Named director of computing sciences for Aerojet-General Corp. He will be responsible for corporate-level policy, planning, control and coordination of automatic data processing operations at the company's various plants and computing centers.

Dion M. Cairns: Appointed controller of SDS Data Systems. He will be responsible for management planning and reporting, accounting, systems and procedures, and data processing.

Alan W. Drew: Appointed president and chief executive officer of Friden, Inc., a subsidiary of Singer Co. He succeeds **Philip R. Samwell,** who has been appointed chairman of the board of directors.

Richard E. Crumley: Appointed vice president, marketing, of David Industries. He will be responsible for the general marketing activities of the parent company as well as for all the individual subsidiaries.

Bud Kallen: Elected executive vice president of the Ray Miller Companies. He has been with the company for the past 14 years.

Robert S. Hultmark: Elected vice president of marketing and administration at Astek Instrument Corp. For the past year, he has been director of administration and assistant secretary of the corporation.

Robert A. Grim: Named vice president, manufacturing, for Defense Electronics, Inc. One of the original co-founders of the firm, he was formerly director of manufacturing.

Dr. Clyde Williams: Elected chairman of the board and a director of Aerospace Controls Corp. He is president of Clyde Williams and Co. and is well known for his contribution in the development of the Xerox process.

Paul Miller: Named executive vice president at Information Handling Services, Inc. **Gardiner Hempel** has been named vice president in charge of sales.

John L. Kemmerer: Appointed controller of Philco Corp.'s Aeronutronic Div. For the past year, he has been manager, profit analysis, for the company's corporate finance staff in Philadelphia.

Maj. Gen. Don R. Ostrander (USAF-Ret.): Appointed vice president, planning, for Textron's Bell Aerosystems Co. He succeeds **Dr. Richard M. Hurst,** who was named to the new post of executive vice president of Bell Aerosystems.

R. E. Greer: Named a vice president of North American Aviation's Space and Information Systems Div. and *Saturn* S-II program manager. He is a retired Air Force major general and directed several Air Force space programs.

John Jeppson: Elected a director of the Foxboro Co. He is second executive vice president of the Norton Co. and chairman of the board of trustees of Clark University.

Jay R. Reese: Appointed president of Texas Instruments Supply Co. He will assume responsibility for further developing the firm as a distribution and service division of Texas Instruments, Inc.

missiles and rockets
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FEBRUARY

58th National Meeting of the American Institute of Chemical Engineers, Hilton Hotel, Dallas, Feb. 6-9.

21st Annual Conference and Exhibit of the Reinforced Plastics Division of the Society of the Plastics Industry, Edgewater Beach Hotel, Chicago, Feb. 8-10.

1966 International Solid-State Circuits Conference, sponsored by the Institute of Electrical and Electronics Engineers and the University of Pennsylvania, Sheraton Hotel/University of Pennsylvania, Philadelphia, Feb. 9-11.

"Thermal Conductivity Measurements of Insulating Material at Cryogenic Temperatures," a one-day symposium sponsored by the American Society for Testing and Materials, ATSM Headquarters, Philadelphia, Feb. 15.

American Meeting of the Institute of Management Sciences, Statler Hilton, Dallas, Feb. 16-19.

17th Pittsburgh Conference on Analytical Chemistry & Applied Spectroscopy, Penn-Sheraton Hotel, Pittsburgh, Pa., Feb. 21-25.

1966 American Astronautical Society National Meeting on Practical Space Application, El Cortez Hotel, San Diego, Calif., Feb. 21-23.

Symposium on Interdisciplinary Aspects of Radiative Energy Transfer, sponsored by the Space Sciences Laboratory of General Electric Co., the Joint Institute for Laboratory Astrophysics of the University of Colorado, the National Bureau of Standards, and the Office of Naval Research, Sheraton Hotel, Philadelphia, Feb. 24-26.

MARCH

National Conference on Space Maintenance & Extravehicular Activities, sponsored by the Air Force Aero Propulsion Laboratory Research & Technology Division, and the Martin Co., Robert Meyer Motor Inn, Orlando, Fla., March 1-3.

10th Scintillation and Semiconductor Counter Symposium, sponsored by the Institute of Electrical and Electronics Engineers Nuclear Science Group, Shoreham Hotel, Washington, D.C., March 2-4.

The American Institute of Aeronautics and Astronautics Technical Committee Plasmadynamics Conference on Plasma Measurements and their Interpretation, U.S. Naval Postgraduate School, Monterey, Calif., March 2-4.

Third Annual Southeastern Symposium on Government Contracts, sponsored by the Mid-Florida Chapter, National Contract Management Assn., Cherry Plaza Hotel, Orlando, Fla., March 3-4.

Electrical Engineering & Operation Conference, sponsored by the Pacific Coast Electrical Assn., Sheraton Palace Hotel, San Francisco, March 3-4.

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The New-Speak Budget

AS FASCINATING as the Administration's Fiscal 1967 budget is from a financial angle, it is almost equally intriguing in its contribution to the semantics of Johnsonian economics.

Puzzled by some of the more inscrutable passages, we sought the aid of a high official at the Bureau of the Budget. His identity, as is customary in such background budget briefings, must remain off the record.

"Charlie," we said, "we and a lot of other people are confused by this budget."

"Good. Then our effort has not been entirely in vain."

"One thing bothers us in particular. There seems to be something going on out in Southeast Asia. Yet the budget doesn't say what it actually is. Is that a war going on out there?"

"Certainly not." He blanched. "You must keep clearly in mind that this Administration would not involve the country in a war. If you will refer to the President's message, you will see that we have a commitment in Southeast Asia, that the budget provides for sustaining our forces in Vietnam, that we must finance the costs of our efforts in Southeast Asia, that we have special Vietnam costs, that our efforts in Southeast Asia are continuing, that we are faced with certain events in Southeast Asia, we are incurring some unforeseen costs in Southeast Asia, that we are continuing to seek a just settlement in Vietnam, that aggressive forces now are testing our will there, that we must meet special requirements in Southeast Asia, that we have rising costs in Vietnam, but we most certainly do not have a war out there. You'll find, if you look at the budget message carefully, that the President most certainly didn't mention a war in Vietnam. There is a mention of a Korean *war,* but you realize we weren't in a position to . . ."

"Of course. We appreciate your clearing that up, Charlie," we said. "Now it seems that the, er, situation in Vietnam has forced the President to cut the budget of the National Aeronautics and Space Administration."

"Oh, no. No, no, no. Not a budget cut. No, sir. If you will look on page 91 of the budget, you will see there the exact words describing what happened. As it says, *the scope of the program for 1967 has been selectively formulated in accord with the overall priorities.*"

"Thank you. On another subject, Charlie, we notice that we are continuing our program of unmanned planetary exploration by sending *Mariner* spacecraft to Venus in 1967 and to Mars in 1969. The budget says the Mars mission will obtain additional vital information for development of the much larger *Voyager* spacecraft looking toward a landing on Mars in the 1970's. Isn't there something missing there, Charlie?"

"Missing? I don't understand. That's exactly what the budget says we are going to do. It doesn't say anything about something missing."

"We see. The NASA report on postponement of the *Voyager* program because of Vietnam spending must be in error. Charlie, the budget also says that the Dept. of Defense will initiate procurement of the FB-111 in the coming fiscal year."

"That's absolutely correct."

"Just when did you do the R&D on that ship, Charlie? Those funds must have been in the FY '66 budget, eh?"

"No, as a matter of fact, old boy, we'll be doing the R&D on that with funds in the FY '67 and FY '68 budgets."

"You've already decided to buy it before you do the R&D? But what about program definition, and engineering development, and all those other phases which must precede initiation of procurement to assure orderly, cost-effective procurement of military hardware which will give us the most for our military dollar?"

"The Secretary wants this one."

"Oh. Solve the problems later, eh?"

"Absolutely. Important thing is to get this to the boys. We'll fix the problems as they come up. There's nothing American ingenuity can't lick."

"Obviously. Another thing, Charlie. We notice that military space funding is down about 15% as shown in the breakdown. Yet the text says that Defense space spending will continue at about the 1966 level. What about that discrepancy?"

"Let's not get picky, old man. It's a big budget, $112.8 billion in expenditures and $121.9 billion in new obligational authority. Record, you know. Absolutely wizard. Can't be bang-on everywhere, keep track of every paltry $400 or $500 million. If there's one thing we can't stand, it's nit-pickers in the press."

"Now, Charlie, we're just trying to explain a complex budget to the American people."

"That's just it. We don't need your sort of interpretation. Next year, you know, we plan to read the whole budget to the people on television and not give out copies at all."

"If we may come back to the subject, we have one final question. We notice that the budget carefully separates the costs of Vietnam and the cost of running the Dept. of Defense. Now, it always seemed to us that the job of the Dept. of Defense was to take care of the fighting when it comes along. What's DOD for if not to fight whatever wars we get into?"

THAT DOES IT. Get out. You're being completely unreasonable. How in the world do you expect Secretary McNamara to run a cost-effective Dept. of Defense if he has to fight every little war that we get the country into? Obviously we have to keep Vietnam costs separately or the defense budget would be much too big. Bad show, that. Out you go."

"That's all right, we were just leaving," we said, gathering up our papers with dignity. "We have to go home and selectively formulate our toenails."

Thus moved we another year closer to 1984.

William J. Coughlin

satellite communication

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1958

During 1958, a tube for use in ground terminals with sufficient power and bandwidth at X-band was required for satellite communication.

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STATE-OF-THE-ART

1964

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STATE-OF-THE-ART

1966

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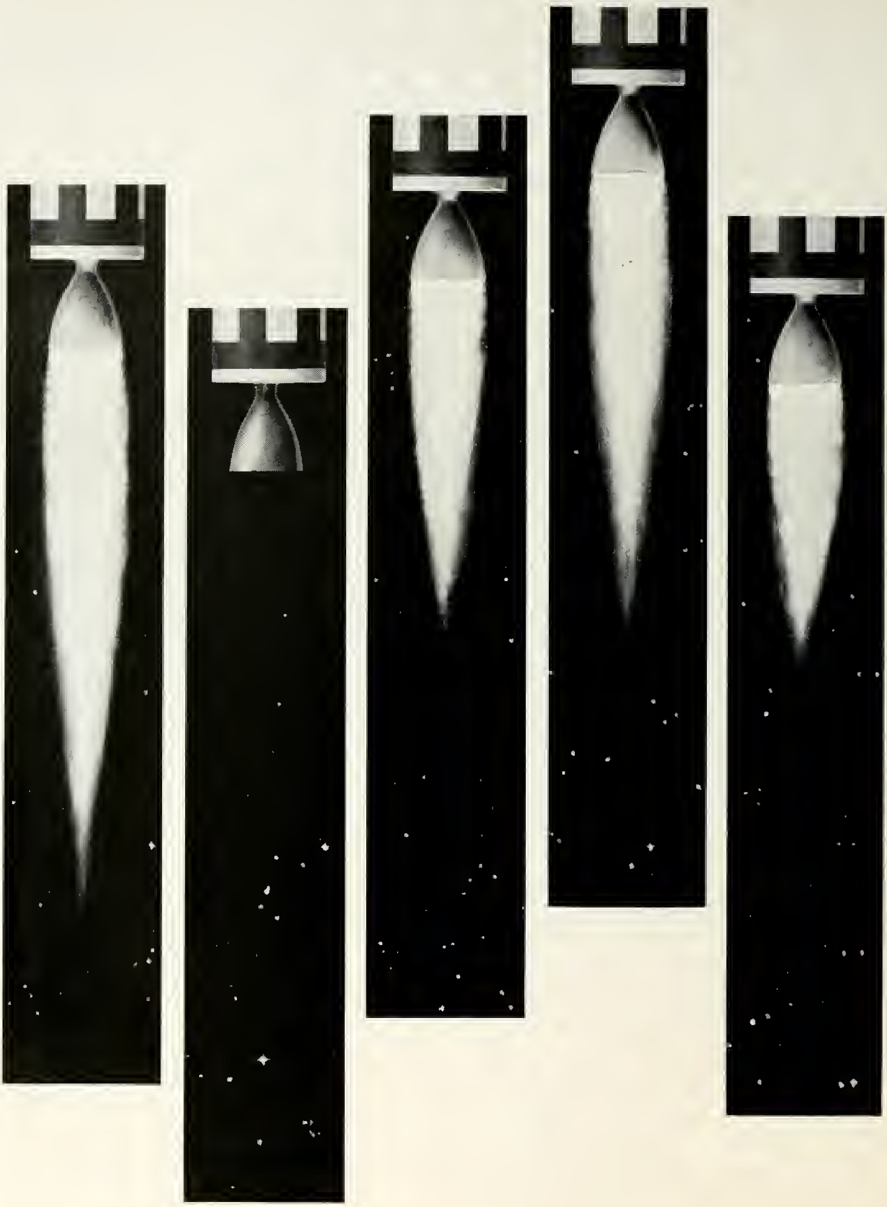

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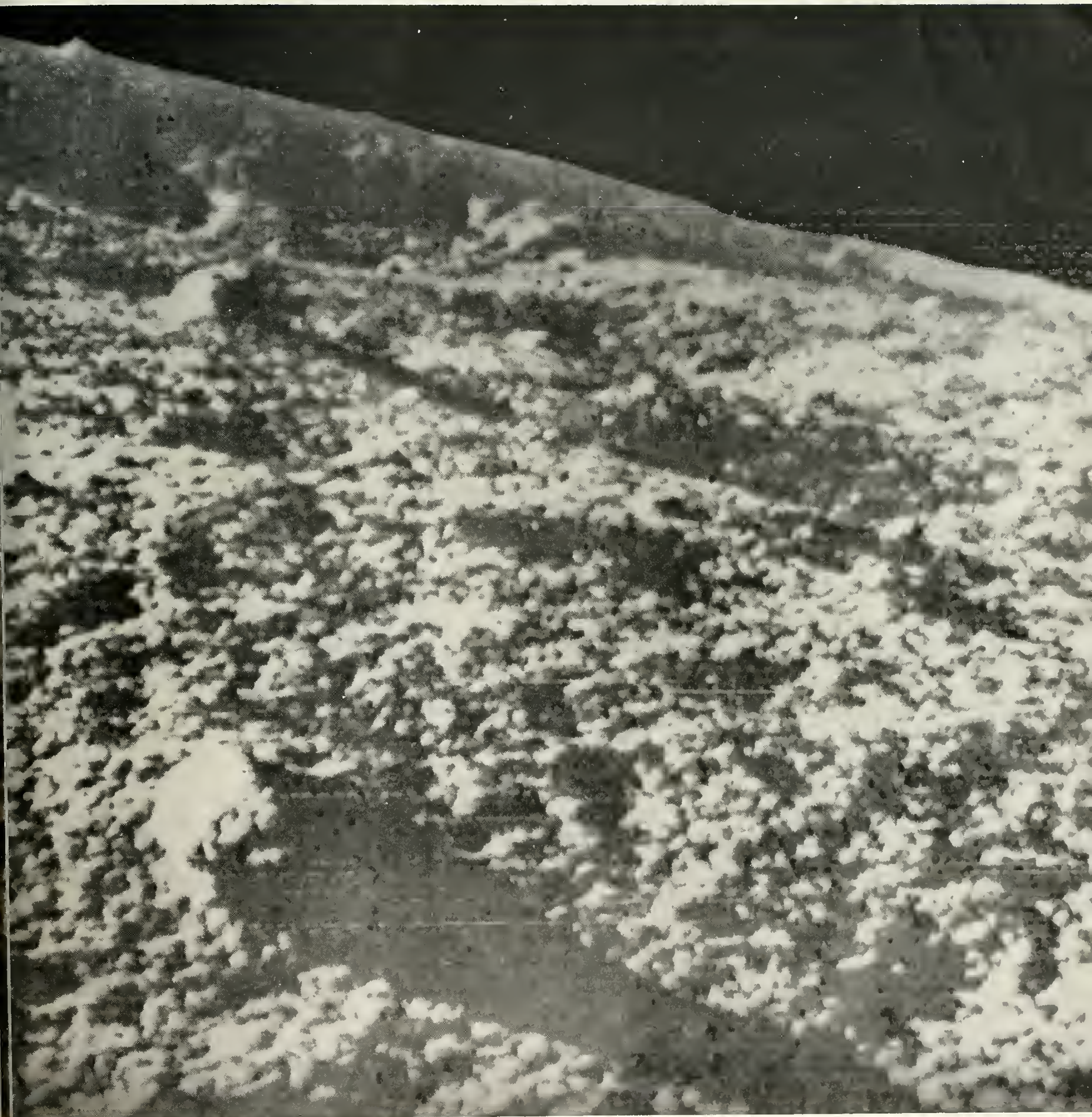

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THE COVER

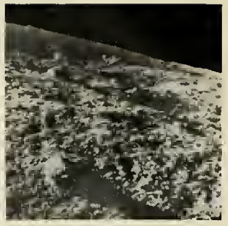

Photo of lunar surface relayed from Soviet Union's Luna 9 probe, which achieved the first soft landing on the Moon Feb. 3. This is one of nine photographs the lander sent before its batteries expired. Objects with diameters as small as one-tenth of an inch were discernible. See page 12.

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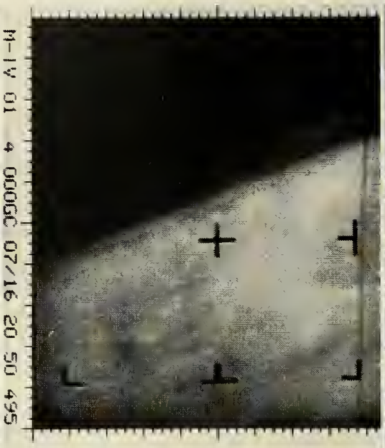
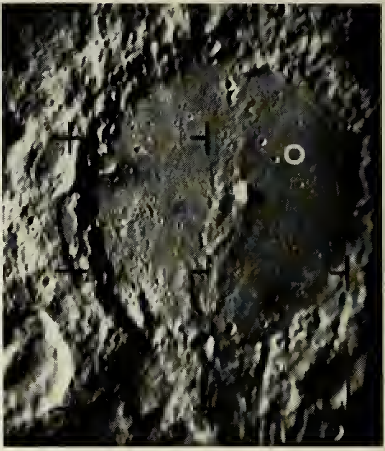
(Among other things)

JPL Observatory at Table Mountain, California.



We captured the first Martian photos with Mariner IV


. . . and this close-up of the crater Alphonsus three minutes before Ranger impacted.

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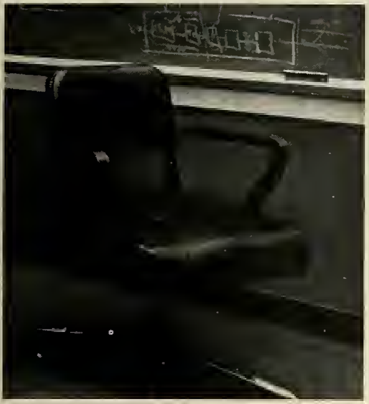

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letters

Hogwash Conference

To the Editor:

Over the years I have become increasingly upset by your editorial bombasts and the "Hogwash Conference" bit (M/R, Dec. 6, p. 46) was the last straw. You are free to print what you like and I choose to no longer contribute, financially, to what I consider M/R's right-wing trend.

Donald R. Allison
Goleta, Calif.

Something of Use

To the Editor:

I wish to congratulate you and your organization for the outstanding job in researching, writing, editing and publishing an excellent and informative magazine for people working in the missile and space fields.

Grover S. Tyler
Missoula, Mont.

A-ICBM Quiz

To the Editor:

I read in M/R, Aug. 16 ("Public Ignorant of A-ICBM Situation," p. 32) that two-thirds of U.S. adults believe in a nonexistent anti-ballistic missile defense."

In *Popular Science*, October, 1965, I read, "Do we have an operational antimissile missile? Most Americans think so. They're wrong." Then it states, "Kwajalein is the only place in the Free World that has an operational missile defense." Yet in M/R's Astrolog, the *Sprint*, which is one of the missiles mentioned in *Popular Science* as operational, is put in the category of development.

Then I called the radar squadron at the military air base near my home. I asked if there are any *operational* antiballistic missiles on the U.S. Mainland. The man on duty said he would check the files. His answer was "Yes, we do have *operational* anti-ballistic missiles." Could it be that we have misinterpreted articles meaning that our defense is not *adequate?*

Perhaps I don't really know what an A-ICBM is. Would you please answer the following questions for me?

1) Is the *Nike-Hercules* an A-ICBM?

2) Is or has the *Nike-Zeus* ever been operational. If it has been, what happened to it?

3) Is the *Terrier* an A-ICBM?

4) What does "tactical" mean in the description of a missile?

5) What, if any, is the difference between a *ground-to-air* or a *sea-to-air* missile and the anti-ballistic missile?

P. L. Clayton, Jr.
Savannah, Ga.

Sprint is in development.

Hercules and Hawk missiles have some effectiveness against battlefield-type missiles but not against ICBM's. The U.S. has no operational anti-missile missile system.

1) Nike-Hercules is not an A-ICBM.

2) Neither Nike-Zeus nor its follow-on, Nike-X, has ever been operational.

3) Terrier is strictly an antiaircraft weapon.

4) "Tactical" means employed in limited, temporary battle zones.

5) Existing ground-to-air and sea-to-air missiles are tactical weapons.—Ed.

Overorganization

To the Editor:

Although it may be a little early to tell, it looks like the United States has been "had" once again because of its insistence on super-sophistication in the design and construction of its spacecraft.

The Russians' *Luna* craft, which scored such a scientific and propaganda coup, appears to be a relatively simple animal—certainly far less complicated than the *Surveyor* which we have yet to get off the ground.

The Soviets now have a substantial lead over us in lunar exploration, and may well widen the gap in the next few months. They probably are getting much more data out of *Luna 9* than mere (though excellent) photographs—and I would wager are getting it for a far lower expenditure than would be the case in a U.S. program.

None of this comment, obviously, is meant to detract from the excellence of our research and development work and the hardware it produces. What I protest is our too-frequent tendency to go hogwild in making equipment super-redundant, super-expensive and far fancier than a given mission requires.

The complexity required for, say, a *Mariner* mission can be a senseless burden when it's applied to a mission that is essentially much simpler. This has gone on long enough.

Frank Adams
Denver

Stock Index Appreciator

To the Editor:

I thought I'd write just to say how handy I have found your missile/space stock index. It's become a "must" in my weekly reading.

Steve Kula
Cedar Rapids, Iowa

Reprints of M/R Index

Reprints of the editorial index of articles appearing in MISSILES AND ROCKETS during the last six months of 1965 are available at no cost from:

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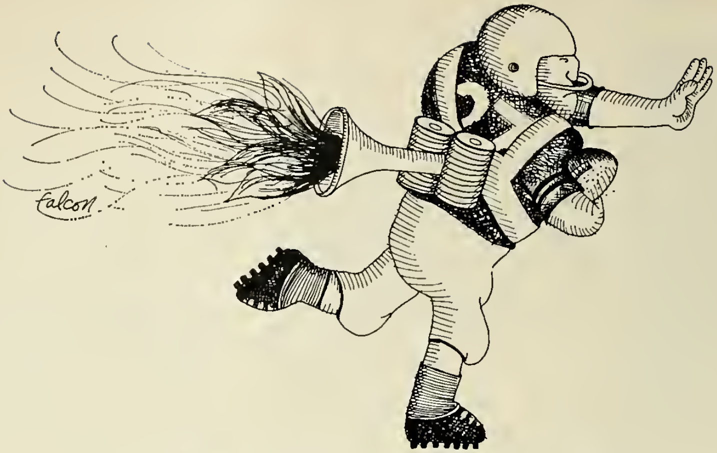

will space vehicles ever run a "broken field" on the way to a touchdown on the moon?

Sooner than you think! Right now Thiokol is developing a propulsion system that will give space vehicles the maneuverability of a touchdown bound half back picking his way through a broken field. The official designation of the assignment; "The C-1 Common Engine." Take our word for it. There's nothing common about the challenge. Starting salaries are substantial. Fringe benefits are excellent. Best of all, the work couldn't be more professionally satisfying. You'll get plenty of opportunity for individual thinking. The full scope of your experience will be put into play. In fact if you don't pass up a foot ball game for the pleasure of working . . . well we'll be surprised.

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The Countdown

WASHINGTON

U.S. Kept Luna 9 Photos Under Wraps

U.S. officials report that this country did receive the pictures transmitted by *Luna 9* but did not release them lest they reveal intelligence methods. Most likely reception point, observers concluded, would be U.S. tracking stations in Turkey—close enough to the Soviet Union to receive the transmission almost simultaneously with Moscow. The Soviet Union shut down the transmission periodically to prevent a USAF tracking station in New England from picking up the signals.

NASA Starts Space Cooperation Search

An advance group of NASA officials is leaving for Europe this week to discuss possible cooperation with those nations. Among the cities they will visit are London, Bonn and Paris. Delegation will include Homer E. Newell, associate administrator for space science and applications; Dr. George E. Mueller, associate administrator for manned spaceflight; and Arnold Frutkin, director of the office of international programs. After sounding out European officials as to what cooperative programs they might like to join, the group will report back to Administrator James E. Webb, before he goes to Europe to initiate formal discussions. Best bet for early cooperative projects now appears to be in the unmanned, planetary area.

MOL Needs Jolt from USSR

Congressional backers of the Air Force's *Manned Orbiting Laboratory (MOL)* program are looking for a Russian manned spaceflight spectacular to drive the apparent lethargy out of the project. Some activity along the space station line is expected in the near future.

Legislators Seek to Cut Foreign Research Aid

A group of Congressmen is moving to reduce the amount of federal funding going out of the U.S. to foreign scientists. The research and technical programs subcommittee headed by Rep. Henry Reuss (D-Wis.) has already taken testimony from Dept. of Defense, NASA, the Atomic Energy Commission and other agencies. It will reconvene Feb. 24 to hear Dr. Donald F. Hornig, the President's science advisor.

Mariner Mars System Support Award Awaited

NASA is expected to initiate a system support contract with an industrial firm for the *Mariner* 1969 Mars spacecraft program. JPL would continue to have prime field-center responsibility for its management. System design is expected to continue through the first half of 1966, with development and testing to run from mid-1966 to the first half of 1968.

Navy in Market for More ADP

Navy is evaluating the automatic data processing requirements of its various types of commanders—such as the Atlantic and Pacific commanders of Navy air and submarine forces and the heads of cruiser-destroyer groups. The study, which will be completed by the end of the year, is expected to create substantial new business for ADP firms.

IDSCP Soon To Get Off Ground

Next *Titan III-C* launch will carry seven *IDSCP (Initial Defense Satellite Communications Program)* satellites and one gravity-gradient experimental satellite. Shot is scheduled for May.

Grissom Moves Toward Apollo CP Role

Virgil "Gus" Grissom appears to have the best chance of becoming command pilot for the first manned *Apollo* flight later this year. He served as director of the *Gemini* program in the astronaut office before being named command pilot for the first U.S. two-man spaceflight. Last week, he was named to head the *Apollo* program in that office, so it appears that history will repeat itself.

INDUSTRY

RCA Studying Color TV from Space

Astro-Electronics Div. of Radio Corporation of America, Princeton, N.J., has received a $40,243 contract from NASA's Manned Spacecraft Center to study real-time transmission of color television to Earth from near-Earth orbit using a communications satellite for relay, and from lunar orbit and lunar surface via S-band communications link. RCA is building the *Apollo* TV (black and white) camera to be used during Block I Earth-orbital missions, and Westinghouse Electric Corp. is supplying the TV cameras that will transmit video to Earth from the Moon's surface.

Space Labs To Supply Apollo Medical Monitors

Space Labs, Inc., Van Nuys, Calif., will be building biosensing instrumentation for medical monitoring during *Apollo* manned missions under a $630,000 contract from Manned Spacecraft Center. Equipment will consist of an impedance cardiograph, vector cardiograph, phono cardiograph, and electro-encephalograph.

Sandia Picked To Direct AEC Isotope Work

Atomic Energy Commission has selected Sandia Laboratory, Albuquerque, N.M., to provide technical direction to its space isotope power program. Actual development work on the system will continue to be handled by industrial firms. Sandia has been conducting the AEC's aerospace nuclear safety program since 1962.

PRC Taking Long Look at Ocean Research

Planning Research Corp., Los Angeles, has undertaken a study aimed at determining total demand for all ocean research work in future years on behalf of the Oceanic Foundation in Oahu, Hawaii. The same survey will assess the potential demand for the specific oceanic research services offered by the foundation's subsidiary, the Oceanic Institute. M. E. Hawley, general manager of PRC's Systems Economics Div., will direct the study.

INTERNATIONAL

U.S. Discloses Hawk Sale to Iran

Confirming a report in the Cairo press, the U.S. Dept. of State last week confirmed that *Hawk* anti-air missiles are being supplied to Iran as part of a five-year military agreement concluded in 1964. Iran thus is the third Middle Eastern nation to get the weapons. *Hawks* were sold to Israel in 1962 and will soon be going to Saudi Arabia.

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Nuclear Transportation Backed

A joint resolution has been introduced in both houses of Congress to establish a commission on nuclear-powered transportation.

Purpose of the group would be a one-year study to determine ways for the federal government to encourage and promote the use of nuclear power in land, sea, air and space transportation.

According to Sen. Warren G. Magnuson (D-Wash.), who introduced the bill in the Senate along with Sen. John Pastore (D-R.I.), vice-chairman of the Joint Committee on Atomic Energy, the resolution stems from a feeling that presently there is no coordination or correlation of the potential of the use of atomic power in all transportation fields.

The proposed commission would have up to 15 members appointed by the President to represent each house of the Congress, appropriate departments and agencies of the government, private industry and other interested groups.

Apollo Astronaut Duties Named

New astronaut assignments in the *Apollo* area within the Manned Spacecraft Center's astronaut office have been announced by NASA.

Virgil I. Grissom has been named chief, *Apollo* branch. James A. McDivitt and Edward H. White II will continue on Command Module development while L. Gordon Cooper, Jr., and Donn F. Eisele will follow Lunar Excursion Module development.

Other *Apollo* assignments include: Frank Borman, boosters and spacecraft propulsion; Rodger B. Chaffee, communications and flight control; Walter Cunningham, electrical and sequential systems.

Walter M. Schirra, Jr., has been named to head the operations training branch with William A. Anders responsible for environmental, radiation and thermal control systems; Alan L. Bean, recovery operations; Russell L. Schweickart, guidance and navigation systems; Clifton C. Williams, Jr., range operations and crew safety.

M. Scott Carpenter will head the advanced programs branch into which scientist-astronauts are assigned. Joseph P. Kerwin is responsible for pressure and extravehicular activity, and F. Curtis Michael, for inflight experiments. Edward D. Gibson, Owen K. Garriott and Harrison H. Schmitt are in flight training at Williams AFB, Ariz.

The *Gemini* branch, headed by Thomas P. Stafford, includes the *Gemini 8, 9,* and *10* mission crews.

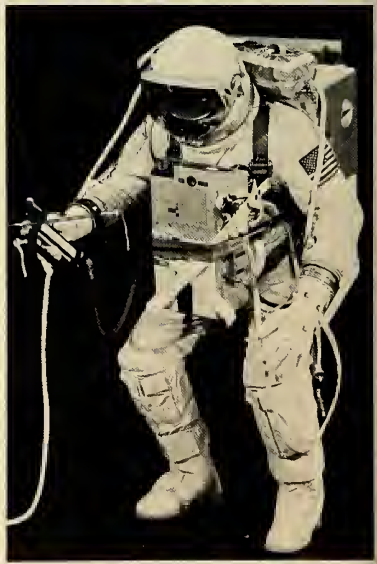
Alan B. Shepard, Jr., remains chief of the astronaut office.

Missile Procurement Drops

Dept. of Defense spending for missile and space systems for the first quarter of Fiscal 1966 totaled \$1,166,718,000, a decrease over the same period for the previous year.

The FY '66 figure amounted to 16.7% of the total DOD procurement. Fiscal '65 spending for missile and space systems was \$1,388,392,000, or 22.9% of the total, according to a DOD announcement.

Procurement of electronics and communications equipment for the



EVA Equipment Shown

Test subject from NASA's Manned Spacecraft Center wears spacesuit and extravehicular equipment planned for use by Astronaut David R. Scott during Gemini 8 flight. Helmet has a gold-plated visor to shield astronaut's face from unfiltered Sun rays. System is composed of a life-support pack worn on chest and support pack worn on back. Scott will be connected to spacecraft by means of a 75-ft. tether line.

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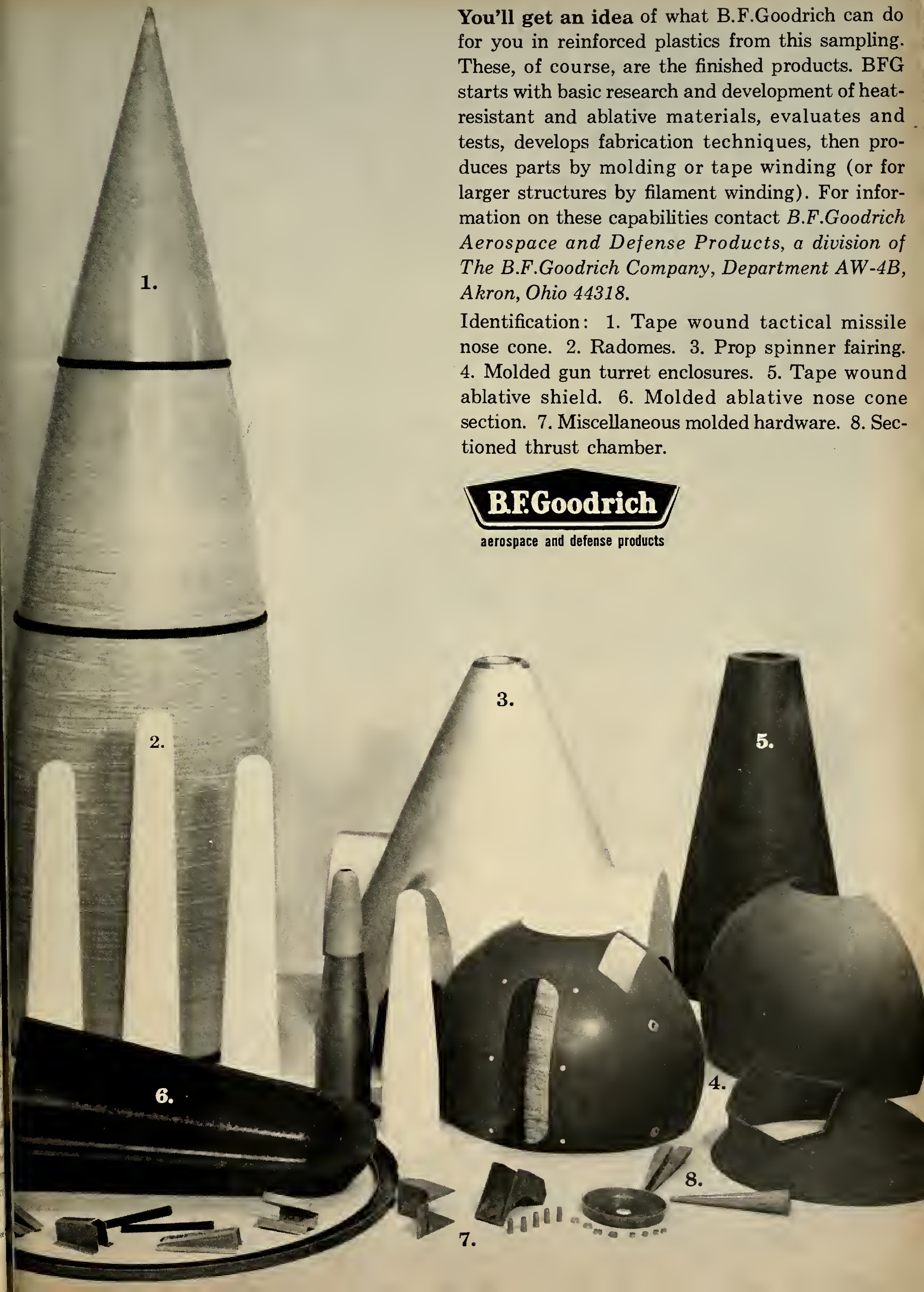

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FY '66 first quarter was $532,859,000, compared to $487,063,000 for the FY '65 period. DOD spent $2,051,526 for RDT&E work during the first quarter, compared to $3,111,946 for the FY '65 period.

GD/Convair To Update Atlas

General Dynamics Convair Div. has been awarded an Air Force contract to refurbish and update 23 retired *Atlas* ICBMs for research and development flights.

Dollar value of the contract, awarded by the Air Force Ballistic Systems Div., is approximately $4 million.

The *Atlas* missiles are series *E* and *F* versions, produced originally by General Dynamics for use in the U.S. strategic missile deterrent force.

The vehicles will be refurbished and recertified to launch upper-stage vehicles for the ABRES (Advanced Ballistic Re-entry Systems), *Nike* target, and scientific satellite programs.

Under previous contracts with the Ballistic Systems Div., 22 series *D* missiles have been refurbished. Twelve have been launched for ABRES, *Nike* target and scientific missions. Eleven of the twelve updated *Atlas* vehicles flew successfully.

Updating of the first 23 series *E* and *F* vehicles will be done at the Convair Div.'s Kearny Mesa plant at San Diego, Calif. About 140 of the missiles are available for refurbishment.

AF Sets Up Missile Support Unit

The Air Force Missile Development Center, Holloman AFB, N.M., has established a new directorate of technical support to integrate certain range support and data processing activities into a tighter operational unit.

The move is part of an MDC reorganization in its mission area to provide more efficient management. Col. Walter L. Carss will head the new directorate.

The center has also redesignated all top-level mission elements—those reporting directly to the center commander—as directorates rather than deputies. A directorate of test track has also been established under the control of Col. Lawrence H. Ballweg.

Athena Program Extended

Thirty-six additional *Athena* vehicles will be funded by Air Force's Ballistic Systems Div. in support of the ABRES program.

The initial funding increment is $300,000, with the total expected to reach $14 million. The work will be split on a 60-40 basis between Atlantic Research Corp.'s Missile Systems Div., Duarte, Calif., and the Green River, Utah, launching area. ARC is the prime contractor for the *Athena* program.

The new extension will carry the *Athena* effort beyond the 77-vehicle program now in being. Some 37 *Athenas* have been fired since the launchings began in February, 1964.

The four-stage vehicle pushes a nominal 50-lb. payload some 100 miles high and then drills it back through the atmosphere reaching reentry speeds similar to that of an ICBM. Launchings are from Green River to the impact area in the White Sands Missile Range, N.M.

The *Athena* program is designed

NERVA Engine Passes Test

The NERVA breadboard engine system was successfully power-tested Feb. 3 at the Space Nuclear Propulsion Office's Jackass Flats, Nev., facility. It was the first test of the complete propulsion system combining the NERVA reactor and other engine components. The test series will continue for several weeks.

to provide information on re-entry phenomena for ballistic missiles.

Shots of the Week

The Air Force successfully fired an *Athena* test missile from Green River, Utah, Feb. 3. The re-entry vehicle impacted on the White Sands Missile Range, N.M. (See related story on p. 10.)

Voyager Schedule Outlined

Development of the *Voyager* spacecraft bus and landing capsule will get under way early in 1969, some 4½ years before launch.

Donald P. Hearth, *Voyager* program manager in NASA's Office of Space Science and Applications, told the recent Winter Convention on Aerospace and Electronic Systems, that mission design for *Voyager* will continue up to the first quarter of 1967. An RFP for preliminary design phase of the *Voyager* capsule will be put out at the end of 1966. Late in 1967, an RFP for the system design phase of both spacecraft and capsule will be issued.

Penetration Aids Pact Let

A $21-million letter contract for an Air Force advanced penetration aids system has been awarded Avco Corp.'s Research and Development Div.

The system will be designed for compatibility with advanced *Minuteman* weapon systems.

The contract will be supervised by the Air Force Systems Command, Ballistic Systems Div. Approximate duration of the design, development and test program will be 28 months. Initial flight testing will be conducted at White Sands Missile Range, N.M. Later flight tests will be launched from Vandenberg AFB, Calif.

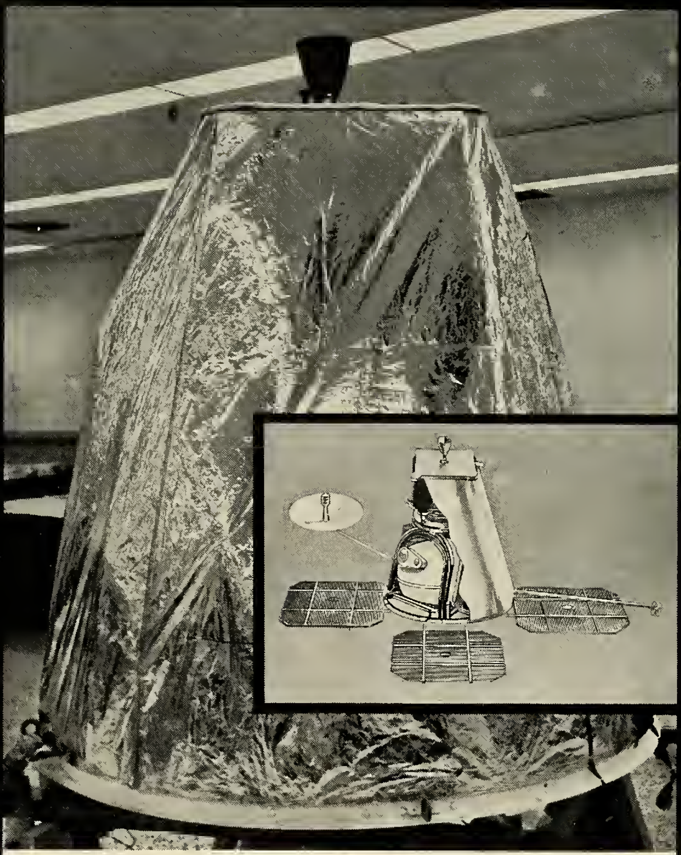
WTR To Control Apollo Ships

Control of five *Apollo* support ships now undergoing modification and instrumentation will be transferred to the Western Test Range, the Air Force has announced.

The ships—formerly managed by the Eastern Test Range—are the USS Vanguard, Mercury, Redstone, Huntsville and Watertown (M/R, Jan. 24, p. 24). They are part of a 17-ship fleet under jurisdiction of the Air Force Systems Command's National Range Div.

ETR will retain "ship instrumentation and engineering responsibility" for the fleet.

New: Schjeldahl Thermal Balance



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Luna Photos Encouraging for Surveyor

Soviet soft-landing feat and pictures indicate no need to change design; experts still debate whether surface is dust or lava

by Rex Pay

SPACE AGENCY officials report that the success of the Russian *Luna 9* spacecraft will not affect the design and scope of this country's *Surveyor* program.

And, despite the excellence of the nine photos transmited back to Earth, the Soviet feat has not settled the long-standing argument as to whether the lunar surface is made up of lava or dust.

Luna 9 was launched on Jan. 31 and landed gently on the Moon at 1:45 p.m. EST on Feb. 3. As reported by the Soviet Union, the spacecraft weighed 3,000 lbs. According to Soviet reports, the foreground of the photos showed objects with a diameter of one tenth of an inch and near the horizon a mile away, objects several yards wide could be identified.

In discussing the effects on the *Surveyor* program, NASA officials said that none of the pictures revealed any topographical hazard for the *Surveyor* soft landing. They also said that the U.S. soft-landing retro propulsion system should be sufficient to land it gently on the surface. *Apollo* program officials also expressed encouragement over the implications for manned landings.

Surveyor will weigh only 2,100 lbs. and should be able to land on a surface which has already proved it can handle at least 3,000 lbs.

Dust or lava?—U.S. scientists interpreting the pictures continued to disagree as to the makeup of the lunar surface. Dr. Gerard P. Kuiper, head of the lunar and planetary laboratory, University of Arizona, and principal investigator for the *Ranger* photographic experiment, declared that the photos put to rest once and for all the theory that the Moon is covered by a heavy layer of dust.

Dr. Leonard Jaffe, JPL *Surveyor* scientist, said, however, that he wasn't sure that the photos disproved the dust theory. He indicated that the areas photographed might be a disturbed area or, possibly, coarse dust.

His position was supported by Dr. Thomas Gold, director of the Center for Radio Physics and Space Research at Cornell University, who said that it was dangerous to guess, merely from appearances in a picture, the composition of a material on an alien body.

He said that since the Moon lies in a vacuum, it is possible that dust under those conditions could take on an appearance very similar to the areas photographed by *Luna 9*.

"Certainly they are excellent pictures. There is no doubt about that," commented Jaffe. "Obviously the surface is somewhat rough, but one thing you worry about is whether it is an undisturbed surface," he added.

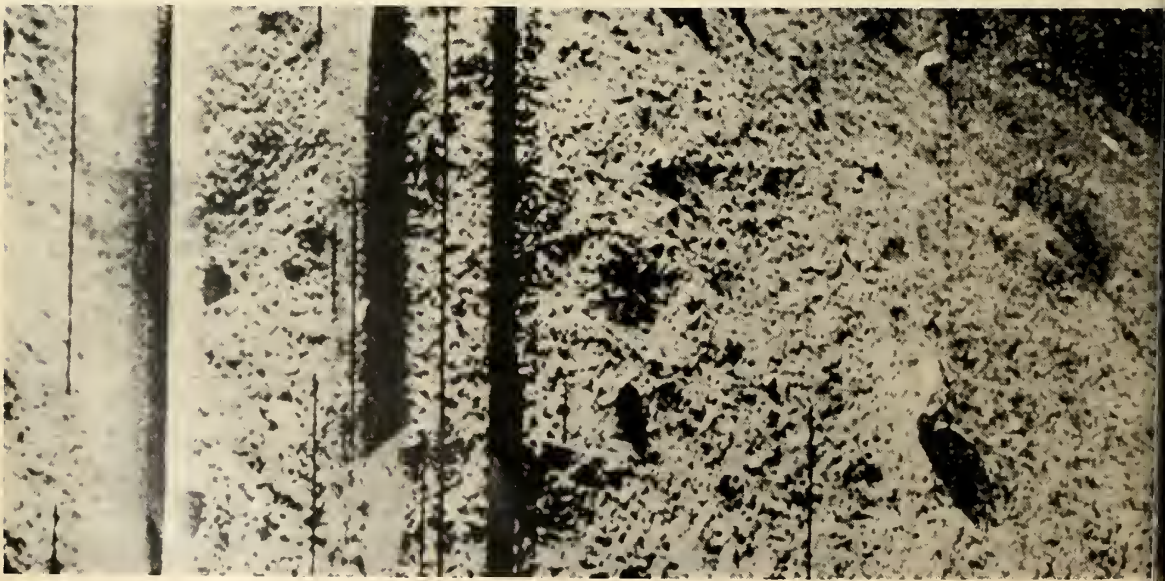
Jaffe pointed out that in the Soviet pictures there is a line beyond which the surface seems to get much smoother. This might indicate that the surface was disturbed by the landing of the capsule, or the capsule could be sitting in a little crater where it is rough.

Surface still mystery?—As to what the surface is, Jaffe (unlike Kuiper—see below) thought the answer at this stage would still be guesswork. "One certainly gets the impression that there are small holes, but this could be an effect of the illumination," he commented.

He noted that the *Ranger* pictures showed a relatively smooth surface, whereas the Soviet pictures showed a rough surface. He suggested this could be due either to the finer scale of the Soviet lunar pictures or to disturbance of the surface during landing.

"I am not at all sure that these pictures throw out the so-called dust concepts of the lunar surface," said Jaffe. "Possibly this is a disturbed area. Or possibly it is a coarse dust."

Jaffe pointed out that the Russian estimates of 1.5 km as the distance to the horizon meant that the spacecraft could not be sitting in a very deep hole. The angle of the horizon suggested that the spacecraft might be tilted. Whether this was intentional is impossible to say.



It may be on a local slope of 15 degrees.

Superior resolution—The pictures provided by the Russians indicated that a 360-deg. panorama was achieved with relatively few pictures. *Surveyor* by contrast has a much narrower viewing angle and would have to take 150 pictures in the wide-angle mode to obtain a panorama. In the narrow-angle mode it would have to take over 1,000 pictures.

One estimate of the Soviet picture process is that it involved some 1,100 lines per scan. This provides pictures that look very much better aesthetically than will the *Surveyor* pictures.

These will have 200 lines if transmitted through the spacecraft's low-gain antenna or 600 lines if transmitted through the spacecraft's high-gain antenna. The actual resolution of surface details by *Surveyor* may be higher, however, because of the use of lenses with narrow fields of view.

Some people at JPL think that the Soviet spacecraft might be very similar to the *Ranger* Block 5 concept—a spherical spacecraft that can survive a fairly rough landing, roll around, right itself, and scan its surroundings by means of a facsimile device. The petals shown in the Soviet sketch of the *Luna 9* could either be for thermal control or, more likely, a means of righting the spacecraft no matter at what angle it falls.

Advantage of simplicity—The picture of the *Luna 9* came as a shock to some people at JPL, who expected to see something that looked pretty much like *Surveyor*.

It would not come as a shock to certain parts of industry and the scientific community who have been advocating that the *Ranger* Block 5 type of spacecraft could fly two or three years ahead of the complex *Surveyor*. As the Russian pictures have confirmed, a spacecraft that takes only a few pictures on the lunar surface during a short period can produce data of inestimable value for science, lunar spacecraft engineering, and national prestige.

Examination of the Soviet pictures led Kuiper and his colleagues at Tucson to take the view that they were quite consistent with the predictions they have presented to NASA on the basis of *Ranger 7, 8,* and *9* pictures.

"The maria are covered with a lava top surface, very rough. It is a foamy vesicular type of lava that results from it being laid down under vacuum conditions. It is a very open extreme form of pumice, 95% of the volume being occupied by cavities, 5% by silicates," said Kuiper.

"I think that the data are entirely compatible, and in fact a beautiful extension of what the *Ranger* pictures told us," he added.

Kuiper said his team's estimate of the bearing strength of the lunar surface, based on the *Ranger* pictures, was about 1 ton per sq. ft. "I see no reason to revise that figure on the basis of the Russian landing," he said.

"There is no evidence of dust. The notion of a large layer of dust was utterly fantastic anyway. This is completely out now, fortunately; it has been a terrible distraction to the lunar studies."

90% safe—Kuiper noted that the Soviet pictures do not indicate, as *Ranger* does, that there are many collapsed depressions on the lunar surface. Although most of the surface has adequate bearing strength, there are extremely treacherous areas. "Maybe on 90% you can land safely," suggested Kuiper.

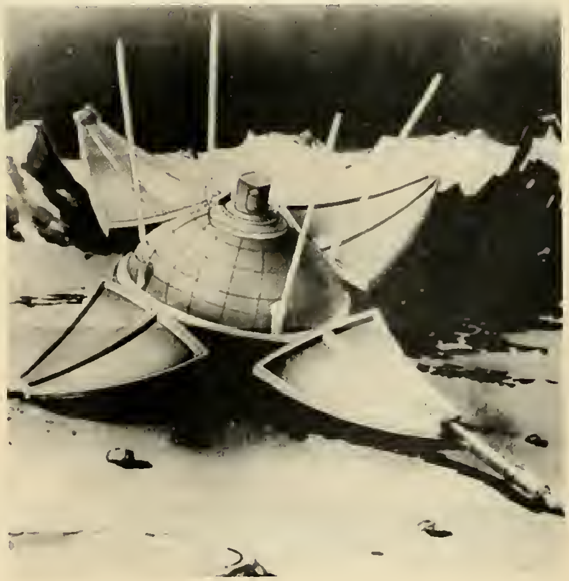
Kuiper noted that toward the horizon the craters in the Soviet pictures were not as flat as might be expected. They presented narrower ellipses than would be found on a flat surface. This in turn indicates that the spacecraft may be in a collapsed depression, with the horizon only a few hundred feet away.

Kuiper said the rocks look much less vesicular than the terrain on which they were resting. They appear to have a density twice that of water, whereas the surface appeared to have a density about one-quarter to one-fifth that of water. It looks as if the rocks came from deeper down, said Kuiper, possibly as a result of meteoritic impact or perhaps due to a breaking of the lunar crust in some other way. "It looks to me as if they have been tossed out from a crater," he added.

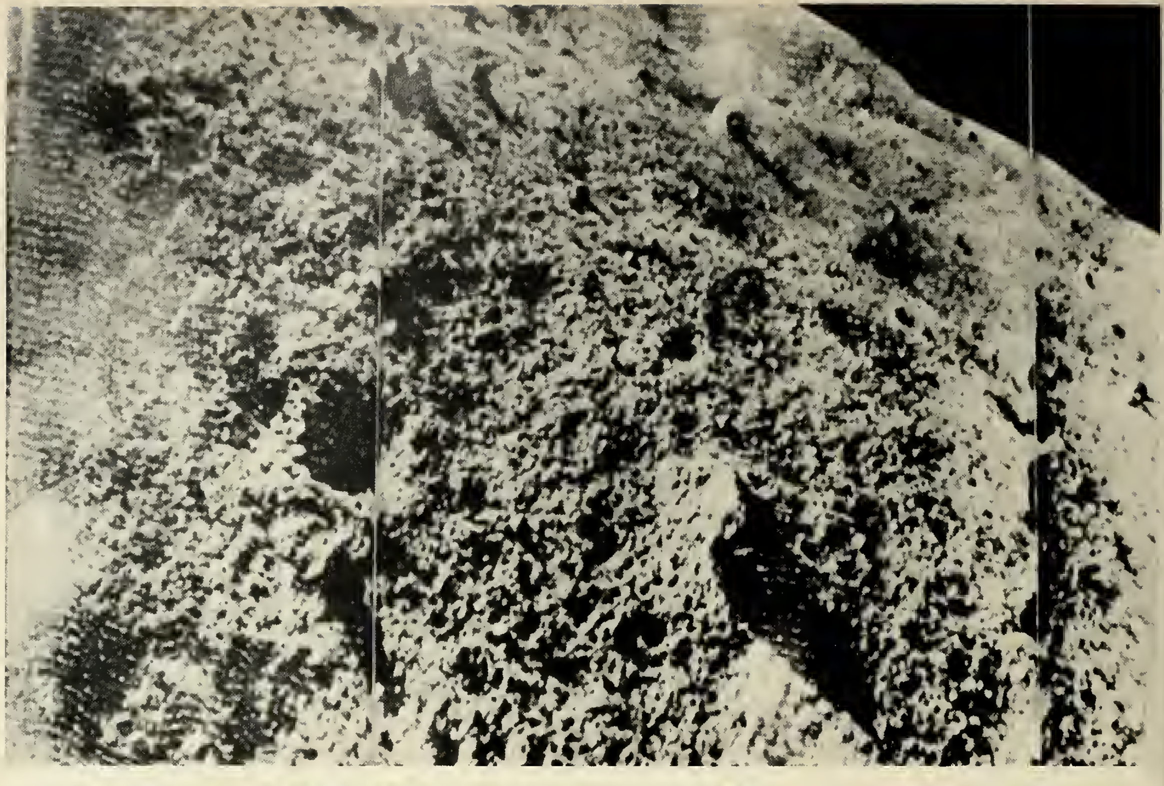
Rocks gain prominence—The difference in density means that the erosion effect of sputtering by the solar wind will remove material from the surface much faster than from the rocks. The rocks will therefore tend to stand out increasingly as time goes on, just as on the Earth a hard lava cap will cause a rock formation to become a pillar.

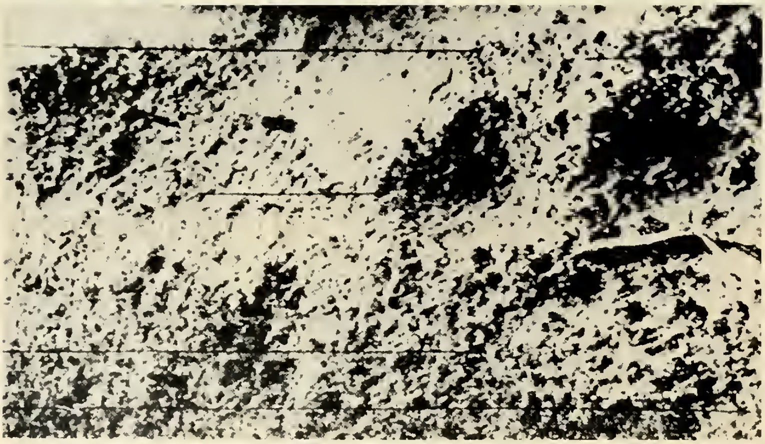
However, there is nothing like the pillars that were revealed in the first pictures released by Jodrell Bank. These appeared because of the gross distortion in aspect ratio that gave a scale error of two and a half. Professor Lovell warned, in fact, that the pictures he first published could be misleading because of absence of camera data. ■

(More photos on page 14)



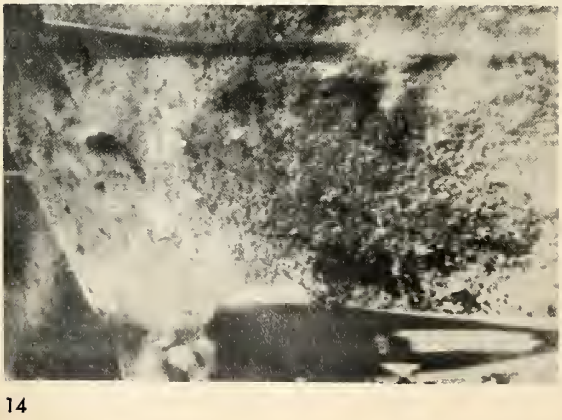
Left: Composite picture of lunar surface was put together by Britain's Jodrell Bank Tracking Station using three photos from Luna 9. Size of pillar-like objects is exaggerated by factor of 2½. Right: Official Soviet drawing of 3,000-lb. spacecraft was released in Moscow on Feb. 4, one day after soft-landing on Moon was achieved.

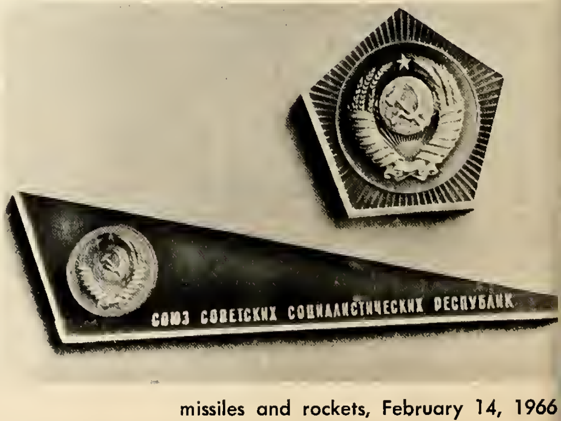




Luna 9 (continued from page 13)

Three lunar surface photos shown here were received by Jodrell Bank Tracking Station near Manchester, England. Top: Shown in great detail are apparent rocket protuberances and craters. Left: A later shot from same spot in Ocean of Storms landing area. Below left: Part of spacecraft appears at bottom of third photo. Below: Two pennants shown in Tass photo were carried to lunar surface by Luna 9. Triangular device bears hammer-and-sickle crest and words "Union of Soviet Socialist Republics." Pentagonal pennant incorporates similar design.





Lunar, Planetary Funds Reapportioned

Space agency reprogramming boosts spending for Surveyor, Lunar Orbiter, Mariner, Pioneer; Voyager, Gemini and Apollo cut back

by Heather M. David

THE *SURVEYOR* PROGRAM is being given an increase of $27.5 million in Fiscal Year 1966 as a result of decisions by NASA to correct deficiences in the program and to support a higher level of manpower at the facilities of prime contractor Hughes Aircraft Co.

The extra *Surveyor* funding is one of several of the lunar and planetary exploration programs requiring reprogramming action by the space agency to make up deficits. Total lunar and planetary exploration budget for FY '66 has risen to $251,337,000, from the $214,915,000 originally authorized.

The increased cost of the *Surveyor* program includes an estimated $10 million in reliability efforts and an augmented test program as recommended by the House Space Committee's space sciences and applications subcommittee headed by Rep. Joseph E. Karth (D-Minn.).

In addition, funds are going to support the level of manpower needed by the prime contractor "to correct problems encountered in the test program and prevent recurrence of these problems on subsequent spacecraft," according to the space agency.

The *Lunar Orbiter* program also has increased in its FY 1966 budget requirements, largely because the prime contractor negotiated subcontracts for more than was planned in the FY '66 budget, and because the prime contractor (Boeing) and the subcontractors underestimated the effort required.

Another program that will receive more money than was originally requested is *Mariner*, which now is slated for $14.2 million to support the already announced initiation of a Venus mission in 1967 and two Mars missions in 1969.

Pioneer robs Voyager—Some $26 million of these funds were made available from the *Voyager* program, which has been cut back to $17 million from the $43 million originally granted by the Congress. This was made possible by deferment of systems design and development contracts that had been planned for FY '66, which would have led to procurement of flight hardware in FY '67. The postponement of the landing goal to the 1973 Mars opportunity made possible deferment of a "substantial portion" of these efforts.

Pioneer also has come into an extra portion of funds, amounting to $4.7 million, because of an increase in the estimated cost of experiments for missions C and D at that time of the negotiation of the definition contracts.

Another $415,000 was recovered from the *Ranger* program.

Final totals in the lunar and planetary programs category show an increase from $84.1 million to $111.6 million for *Surveyor;* $36 million to $52.4 million for *Lunar Orbiter;* $3.8 million to $18 million for *Mariner,* and $8 million to $12.7 million for *Pioneer. Ranger* drops from $1.4 million to $1 million (program completed), *Voyager* to $17 million from $43 million, while supporting research and technology and advanced studies remains at the $38.6-million level.

Another program having some difficulties that require extra funding in FY '66 is *Biosatellite.* Here an additional $5.6 million is being reprogrammed, bringing the total to $21.6 million, because of difficulties encountered with the individual experiments and integration of these into the spacecraft.

The *Biosatellite* will be launched for the first time in the last quarter of this year, NASA said, but the 21-day mission has slipped and will be scheduled after one or both of the 30-day missions.

OSSA reorganization—The *Applications Technology Satellite* program is receiving an increase of $2.8 million, bringing it to $29.5 million, to reflect the redesign of the gravity-gradient experiment.

The new working budget also reflects the combination of the consolidation of the communications and meteorological satellite programs together with the applications technology programs, into a new office known as Science Applications Programs. Budget entities involved are $37.4 million for meteorological satellites and $34.3 million for communications and applications technology satellites.

NASA has named Leonard Jaffe, formerly director of communications satellite projects, to be director of the new Science Applications Programs Office, with Dr. Morris Tepper, former director of meteorological satellite programs as deputy and director of meteorological programs.

Other organizational changes announced by NASA last week in the Space Sciences and Applications Office include renaming the Manned Space Science Programs Office to the Manned Flight Experiments Office/PSSA, and the transfer of some staff members to the program offices involved, such as bioscience, lunar and planetary, physics and astronomy, and space applications.

Not reflected in the FY '66 budget is the transfer of the *Pioneer* interplanetary program to physics and astronomy programs from lunar and planetary, and the geodetic satellite program from physics and astronomy to space applications.

Funding down—Those categories that will not receive the entire appropriated amounts include *Gemini,* which has a planned spending figure of $226.6 million, as opposed to a budget of $242.1 million. *Apollo* is slated to spend the entire authorized amount of $2,967.3 million.

Launch vehicle development planned spending is $55.3 million, out of a possible $63.6 million. Electrical systems is down from $34.4 million to $32.3 million; space power and electric propulsion, $45.2 million out of $47.2 million; chemical propulsion, $39.7 million out of $43.7 million, and tracking and data acquisition, $231.0 million out of $242.3 million.

Administrative operations funds also will exceed the authorized figure. NASA said that the total $5,123.5 million program planned for administrative operations and R&D would be financed by $5,115 million in FY 1966 appropriations, and by using $8.5 million from funds made available from prior year R&D programs.

Other OSSA changes—Some title changes were involved in OSSA's realignment announced last week. The directors of sciences and engineering are changed to deputy associate administrator for space science and applications for science, and for engineering. The former is Dr. John R. Clark; the latter, Robert F. Garbarani.

OSSA also has established an advanced misions staff, which will report to the deputy associate administrator for space science and applications (sciences) as the central coordination point for all OSSA advanced study effort. Acting director is John E. Naugle. ■

How Space Agency Expects To Fund OART and OTDA

by Hal Taylor

NASA's FISCAL 1967 budget request calls for the funding of a host of new advanced technology projects including two *Scout* re-entry flights, an orbital scanner satellite, and development of the *NERVA II* nuclear rocket engine.

The new projects are part of the $278.3-million request for the Office of Advanced Research and Technology, on which hearings will open shortly before the House Space Committee.

At the same time, special budget material prepared for submission to the committee also revealed that the total request of $279.3 million for the Office of Tracking and Data Acquisition includes $199 million for tracking station operations, $66.5 million for new equipment and $13.8 million for supporting research and technology activities.

A breakdown of the budget for OART and OTDA is presented in the table on page 17. It completes Missiles and Rockets' two-part series detailing NASA's research and development funding plans for the fiscal year starting July 1.

NERVA outlook—The initiation of *NERVA* engine development will be based on the Phoebus II nuclear reactor. It will be designed to have a power level of 4,000 to 5,000 thermal megawatts providing a thrust of 200,000 to 250,000 lbs.

The $33.1-million request for the engine includes $6 million for engine development, $9.6 million for component and subsystem development, $15 million for ground testing and $2.5 million for propellants.

Scouts and Scanner—The two new *Scout* re-entry flights are designed to provide some of the data needed to simulate conditions which will be encountered by spacecraft returning from trips to Mars and Venus.

The two re-entry packages will be designed to provide anchor-point data on both the heating environment and the behavior of thermal protection systems.

The space agency said that since systems capable of testing conditions at re-entry speeds of 45,000 to 50,000 ft. per second require long lead times and are difficult to devise, the *Scout* launches will be used to test conditions at the intermediate re-entry speed of 37,000 ft. per sec.

Another flight project to be funded in the next fiscal year is the Earth coverage horizon measurement—otherwise known as the *Orbital Scanner Satellite* system.

The program calls for making a comprehensive measurement of the Earth's horizon radiance profile over a broad range of seasonal and climatic variations. Advanced studies have been initiated in FY '66 to identify suitable flight experiments and in FY '67 the studies will be broadened and completed and the operational requirements for the planned system will move into the systems definition phase.

In the chemical propulsion area, the budget reveals that NASA plans to test various subsystems by firing 120-in. solid rocket motors.

One system which will be tested is a warning device capable of detecting potential failure in solid propulsion systems used for manned vehicles; instrumentation for interpreting the warning signals; and methods for terminating or reducing thrust, so that astronauts may escape.

Tracking and Data Acquisition—In breaking down the operations cost of its tracking stations, NASA said that $60 million will be required for its manned spaceflight network, $33.7 for its satellite network, $32.8 for its Deep Space Network, $57 million for communications, $8.5 million for data processing and $7 million for other instrumentation.

The $26.5-million request for new equipment for the manned spaceflight network will be used to expand the memory capacity of its on-site data processing equipment by 50%.

Equipment changes in the satellite network—with a funding request of $14.5 million—include the replacement of tube transmitters with solid-state transmitters, replacement of the rib mounted command antennas on the 40-ft. and 85-ft., tracking facilitiies with smaller and more reliable antennas and the replacement of existing command encoders at several stations.

The major item in the Deep Space Network equipment cost in FY '67 will be station monitoring and control equipment. The purpose of this program is to implement a single standardized set of equipment at each site which will serve the needs of various flight programs. It will also provide real-time data on an operational status. ■

Test-Firings Promote Agena Hopes as Gemini 8 Target

SUCCESSFUL wind-tunnel tests on the *Agena* upper stage are improving its chances of being selected as the target vehicle for the *Gemini 8* mission.

By mid-week, the modified *Gemini* vehicle had been static-test-fired six times with no indication of any malfunction.

Each of the ignition firings—at the chamber altitude of 250,000 ft.—lasted for five seconds. A total of 28 such firings is planned in the wind tunnel at the Arnold Engineering Development Center at Tullahoma, Tenn.

After the ignition series is completed, the firing program will move into the mission simulation phase, during which a total of eight firings will be made. These include the ascent burn of 180 seconds, a plane-change burn of 15 seconds, and oxygen-depletion burn of 25 seconds.

The third phase in the test schedule is the malfunction series, which includes 11 firings lasting 10 seconds each.

If all tests are performed successfully, the *Agena* will be fired 47 times.

ATDA still in wings—If any malfunctions do crop up, NASA is expected to drop the *Agena* out of the *Gemini 8* mission and switch instead to the *Augmented Target Docking Adapter (ATDA)* as the rendezvous target vehicle.

The 11-ft.-long *ATDA* was shipped to the Kennedy Space Center on Feb. 4 by McDonnell Aircraft Corp., which developed it for the space agency.

If the *Agena* tests are all successful, earliest launch date will be March 15. If the *ATDA* is picked, *Gemini 8* could go as early as March 7.

FY 1967 NASA BUDGET REQUEST FOR ADVANCED RESEARCH & TECHNOLOGY AND TRACKING & DATA ACQUISITION

(in millions of dollars)

OFFICE OF ADVANCED RESEARCH & TECHNOLOGY

BASIC RESEARCH

	1966	1967
Supporting research and technology		
Fluid physics	8.0	8.2
Electrophysics	4.4	4.8
Materials	8.1	8.5
Applied mathematics	1.3	1.5
TOTAL	22.0	23.0

SPACE VEHICLE SYSTEMS

	1966	1967
Supporting research and technology		
Spacecraft aerothermodynamics	6.1	5.3
Spacecraft structures	6.2	6.7
Launch vehicle aerothermodynamics	0.8	1.3
Launch vehicle structures	2.5	3.2
Space vehicle environment factors	7.9	10.8
Advanced space vehicle concepts	0.5	—
Space vehicle design criteria	1.7	1.2
TOTAL	26.0	28.7
Lifting body flight and landing tests		
Flight vehicle and support services	1.0	1.0
TOTAL	1.0	1.0
Scout re-entry project		
Spacecraft and support	3.0	4.8
Scout (launch vehicle procurement program)	(—)	(1.8)
TOTAL (including launch vehicles)	(3.0)	(6.6)
Small space vehicle flight experiment		
Spacecraft and support	2.0	1.5
TOTAL	2.0	1.5

ELECTRONIC SYSTEMS

	1966	1967
Supporting research and technology		
Guidance systems	6.0	6.2
Control systems	6.0	6.1
Communications	4.8	5.6
Tracking and data acquisition	3.5	3.7
Data handling and processing	3.6	4.1
Instrumentation	3.9	4.1
Electronic techniques and components	2.0	4.0
TOTAL	30.0	34.0
Flight projects		
Radio attenuation measurements (RAM-C)	1.3	1.3
Small flight projects:		
(SCANNER)	1.0	—
(Sextant Experiment)	—	0.5
Earth coverage horizon Measurement	—	1.0
Total flight projects	2.3	2.8
Scout (launch vehicle procurement program)	(1.4)	(0.8)
TOTAL (including launch vehicles)	(3.7)	(3.6)

HUMAN FACTOR SYSTEMS

	1966	1967
Supporting research and technology		
Human research and performance	5.1	6.0
Life support and protective systems	4.4	5.8
Man-systems integration	2.9	3.1
Advanced concepts	0.5	0.5
TOTAL	13.0	15.5
Small biotechnology flight projects		
Small biotechnology flight projects	1.9	1.5
TOTAL	1.9	1.5

SPACE POWER AND ELECTRIC PROPULSION SYSTEMS

	1966	1967
Supporting research and technology		
Nuclear-electric power	14.0	13.1
Electric propulsion	10.0	9.8
Solar power generation	9.0	9.0
Chemical power generation	5.1	4.9
TOTAL	38.2	37.0
SNAP-8 development		
Development	4.0	5.5
TOTAL	4.0	5.5

NUCLEAR ROCKETS

	1966	1967
Supporting research and technology		
Rocket reactor research	14.2	11.7
Nuclear rocket engine systems	5.1	3.9
Safety	0.5	0.2
Vehicle technology	1.1	1.0
TOTAL	21.0	16.9
NERVA		
Engine systems development	5.6	6.0
Component and subsystem development	11.8	9.6
Ground test and operations support	15.1	15.0
Propellants	3.5	2.5
TOTAL	36.0	33.1
Nuclear rocket development station operations		
General site support	1.0	3.0
TOTAL	1.0	3.0

CHEMICAL PROPULSION

	1966	1967
Supporting research and technology		
Liquid rocket research and advanced technology	12.7	12.7
Liquid rocket experimental engineering	12.2	12.2
Solid rocket research and advanced technology	5.0	5.0
Solid rocket experimental engineering	3.5	3.5
TOTAL	33.5	33.5
Large solid motor project		
Large solid motor project	4.2	3.5
TOTAL	4.2	3.5

AERONAUTICS

	1966	1967
Supporting research and technology		
Aircraft aerodynamics	2.2	1.6
Aircraft loads and structures	2.0	1.5
Air-breathing propulsion	2.2	3.0
Aircraft operating problems	3.7	2.9
TOTAL	10.2	9.0
X-15 research aircraft		
Aerodynamics	0.2	0.1
Loads and structures	0.01	0.2
Propulsion	—	—
Operating problems	0.6	0.5
TOTAL	0.8	0.9
Supersonic transport		
Aerodynamics	0.8	1.3
Loads and structures	0.1	0.7
Propulsion	11.5	11.1
Operating problems	1.5	1.0
TOTAL	14.0	14.1
V/STOL aircraft		
Aerodynamics	0.7	1.6
Loads and structures	0.008	0.2
Propulsion	0.3	1.0
Operating problems	0.9	2.2
TOTAL	2.0	5.0
Hypersonic ramjet experiment		
Propulsion	5.0	2.0
TOTAL	5.0	2.0
XB-70/SST flight research project		
Aerodynamics	5.1	—
Loads and structures	0.6	—
Propulsion	0.8	—
Operating problems	2.7	2.0
TOTAL	9.2	2.0

OFFICE OF TRACKING & DATA ACQUISITION

	1966	1967
Operations		
Manned space flight network	37.0	60.0
Satellite network	29.0	33.7
Deep space network	26.5	32.8
Other instrumentation	6.6	7.0
Communications	24.0	57.0
Data processing	6.5	8.5
TOTAL	129.6	199.0
Equipment		
Manned space flight	50.3	26.5
Satellite network	15.8	14.5
Deep space network	9.9	10.5
Other instrumentation	4.0	4.5
Communications	5.1	7.5
Data processing	2.5	3.0
TOTAL	87.6	66.5
Supporting research and technology		
New systems	1.1	0.5
Integrated systems analysis, development, and test	2.6	3.5
Antenna subsystems	2.1	1.6
Receiver and transmitter subsystems	2.7	2.3
Data handling and control	2.4	2.1
Data processing and reduction	1.2	2.1
Spacecraft subsystems	1.4	1.7
TOTAL	13.8	13.8

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CHARACTERISTICS

CAVITY AMPLIFIERS	EM4539	EM4596
Frequency, continuously tunable (MHz)	1420-1600	2200-2300
Rf power output (with 2 watts drive)	Frequency (MHz) P_o (watts) CW 1420-1435 . . . . . 15 1435-1535 . . . . . 20 1535-1600 15	20 watts
Bandwidth (Min, 3db points)	10 MHz	10 MHz
Gain (Min)	10 db	10 db
Efficiency, Overall (Min)	25%	25%
Size (Overall, incl. protrusions)	4 x 2½ x 1½ in	3¾ x 2½ x 1½ in
Weight	1.1 lbs	0.95 lbs

POWER SUPPLY EM 4590

Plate voltage . . . . .600, 650 or 700 Vdc, selectable by internal wiring, at 90 to 150 mA

Heater voltage . . . . .5.0 to 6.0 Volts, continuously adjustable, at 0.85 to 0.95 Amperes

Input voltage . . . . .28^{+8}_{-4} Vdc

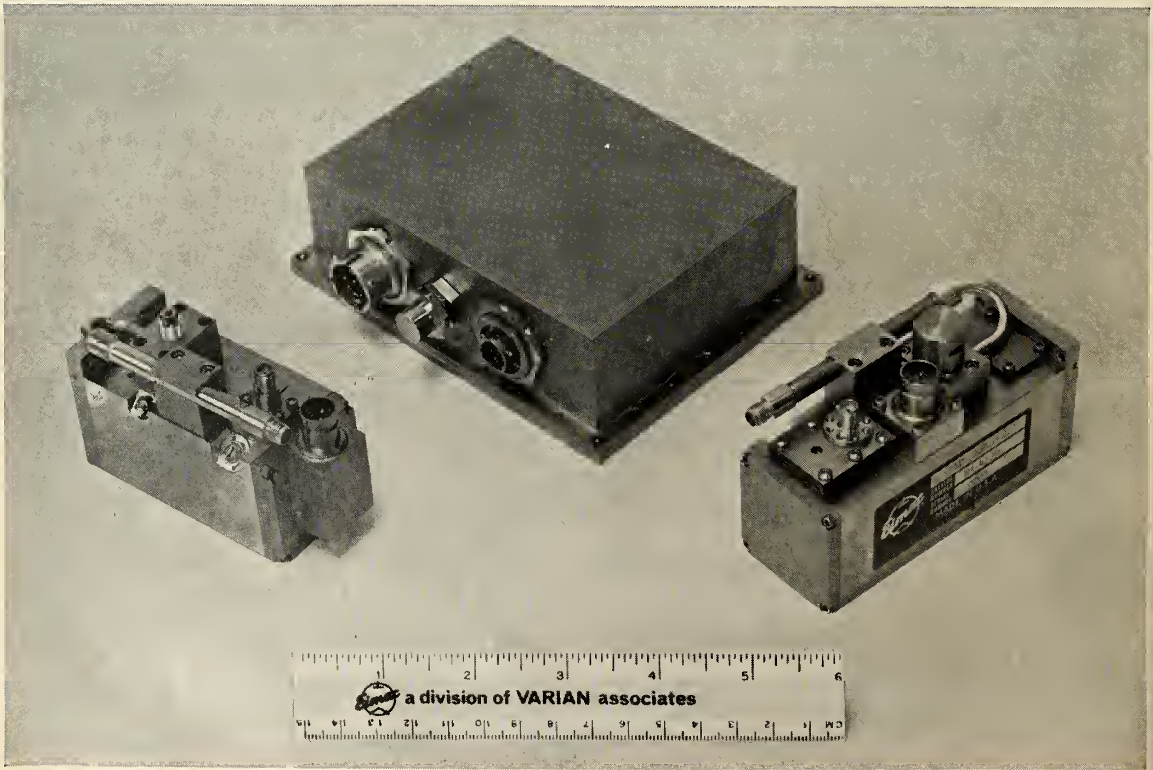
Efficiency, minimum. 75%

Life, continuous or intermittent operation, 95% probability, 60% confidence . . . . .1000 hours

Size, overall (excluding connectors) . . . . .1.7 x 4.2 x 5.5 in

Weight . . . . .2.5 lbs

EIMAC
Division of Varian
San Carlos, California 94070



Circle No. 4 on Subscriber Service Card

Technical Countdown

ELECTRONICS

IBM Computer Programs Integrated Circuits

An experimental computer program which determines how to interconnect 80 electronic circuits on a silicon wafer and controls their fabrication is in operation at IBM's Research Div. The program allows automatic bypassing of any faulty circuits on the wafer, making most wafers usable despite the occurrence of faulty circuits at random positions. Current production method involves cutting the wafer into chips, testing each chip and discarding the bad ones. Computer control of interconnections makes practical the use of silicon wafers containing hundreds of circuits as the first-level package in electronic systems. The program can also generate patterns that allow a standard wafer to be interconnected in different ways to perform different functions. In operation, the computer calculates an acceptable interconnection pattern from programmed criteria. Transferred to tape, the interconnection pattern is written by a beam of tape-controlled light in photoresist on the surface of the wafer. Standard metal-etching techniques produce the actual interconnections.

EOS Working with French Government

The Service d'Aeronomie of the government of France is procuring solar-cell arrays from Electro-Optical Systems, Inc., for use in the *EOLE* project. Dollar figures involved were not announced. EOS will build 20 arrays for delivery to the *EOLE* project, Noumea, New Caledonia, by July, 1966. Each array will consist of 140 cells mounted on thin plastic boards. The project involves a series of balloon flights for wind and other atmospheric experiments.

Walleye Vidicon Tubes Pact Awarded

General Electrodynamics Corp. will continue to produce vidicon tubes for the *Walleye* TV guided bomb. The $239,636 contract was let by the U.S. Naval Avonics Facility in Indianapolis. The *Walleye* is a propulsionless, gravity bomb with a sophisticated guidance system.

First N-Channel IGFETs Fabricated

Scientists at the Sperry Rand Research Center are perfecting development of the first N-channel metal nitride semiconductor insulated-gate field-effect transistors (MNS/IGFET) through a new silicon planar technology. The development promises to cure the electrical instability of present N-channel IGFETs and is based on the substitution of silicon nitride for silicon oxide as a more effective insulating material. P-channel enhancement mode MNS/IGFETs built and tested at the firm have demonstrated marked improvements in electrical stability, lower threshold voltage and greater voltage handling capability over the newest metal oxide semiconductor devices. N-channel devices using the silicon nitride are under test.

PROPULSION

RL-10 Passes Million-Second Mark

Total firing times for Pratt & Whitney's RL-10 liquid hydrogen/LOX engines passed the million-second mark with the firing of an experimental model at the firm's Florid Research and Development Center. A total of 44 engines has now operated successfully in space; 36 of these were used in the six *Saturn* S-IV flights. The United Aircraft Div. is currently increasing the engine's specific impulse under a $19-million contract from NASA's Marshall Space Flight Center.

OCEANOLOGY

Underwater Hearing Aid Developed

Two CBS laboratories researchers have perfected a technique allowing a man to perceive while underwater the direction of arrival of all sounds within the normal frequency range of hearing. Benjamin B. Bauer and Emil L. Torick designed an electronic circuit coupled to hydrophones that varies the relative intensity of electrical signals received by the phones depending on the direction of a sound's arrival. Man's inability to locate the sources of underwater sound is due to a combination of effects—such as the high speed of sound in water and the reception of such sound by both the normal tympanic channel and through bone conduction.

LIFE SUPPORT

Nuclear Heat for Divers

Two developments in the use of nuclear energy in life support systems are under active investigation by the Atomic Energy Commission in cooperation with potential user agencies. AEC is cooperating with the Navy to develop a 300-thermal-watt plutonium 238-fueled source to supply heat to divers by way of fluid transported through vein-like tubes in a diver's swimsuit similar to the *Apollo* water-cooled undersuit. The unit, operated by a backpack, will weigh approximately 15 lbs. and is radiation-safe. The second program is being carried out with the Air Force with closed-cycle water recovery system developed by AiResearch Manufacturing Div. of the Garrett Corp. Mound Laboratory is looking at a plutonium 238 source and Pacific Northwest Laboratories at a promethium 147 source to power the unit.

SPACE MEDICINE

SST Radiation Hazard Checked

The Air Force, NASA and the Federal Aviation Agency are setting up a two-year program which will span part of the solar cycle peak to determine the environmental radiation hazard to be encountered by supersonic travelers. The biophysics branch of the Air Force Weapons Laboratory, Kirtland, N. M., is overseeing development of the experiments. The NASA package, developed at Ames Research Center, will contain sensors to measure the physical parameters of flux and energy distribution for protons and neutrons. The FAA-AFWL will provide flux measurement by a standard-type Geiger tube, dose-rate measurements from tissue equivalent ion chambers, and linear energy transfer spectra of all incident radiation. Passive dosimetry will be provided by the U.S. Naval School of Aviation Medicine.

Space Solid Performance Revealed

Air Force releases figures on Hercules B-3 injection motors used in three successful Vela launches; data show velocity off less than 0.5%

by John F. Judge

PERFORMANCE FIGURES on the solid rocket injection motors used to kick six *Vela* nuclear detection satellites into orbit have been released by the Air Force—a rare event in military space programs.

The powerplants placed the six satellites, developed by TRW Systems, into the correct orbits in three successive launches. The nuclear detection program is managed by the Space Systems Div. of the Air Force Systems Command.

The motors were designed and built by Hercules Powder Co. under contract to TRW. Each uses a high-impulse propellant cast and bonded to a filament-wound glass-reinforced case.

The Air Force figures verify that the B-3 motors performed their function with an exactitude not ordinarily attributed to solid propellant space motors. Post-launch data on the three, twin-satellite launchings indicate that the difference between the calculated and actual velocity was less than 0.5%.

The motors are 31 in. long, 18 in. wide and weigh 214 lbs., fully loaded. The inert case and nozzle account for about 15 lbs. of this weight.

Hercules manufactured the double-base motors to extremely close tolerances to achieve the required precision and deliver the velocity increment in a reliable and reproducible manner.

For instance, the weight of the B-3 units was controlled to a hundredth of a pound.

Operations—The program called for the injection of the TRW twin satellites into a 50,000-mi. circular orbit after the vehicle is boosted to a flat, oval orbit with a 50,000-mi. apogee by the *Atlas-Agena B.*

The third launching, on July 21 and 23, 1965, placed the satellites in a 60,000-mi.-high orbit—the highest ever achieved by a spacecraft. At the time of this launching, the B-3 units were three years old, demonstrating a significant shelf life.

The two satellites were mounted one on top of the other. Following burnout of the second stage, the twins separated from the booster and then from each other. At first apogee, the Hercules motor on the first satellite fired, placing the 524-lb. sentry in its assigned orbit.

The second satellite continued in the elliptical transfer orbit until the injection position was reached. The second Hercules unit was then fired and the satellite was put in position separated from its twin by about 140 degrees.

Including the six motors used in the nuclear detection flights, some 67 consecutive successful firings have been achieved for a reliability of 0.966 at a 90% confidence level.

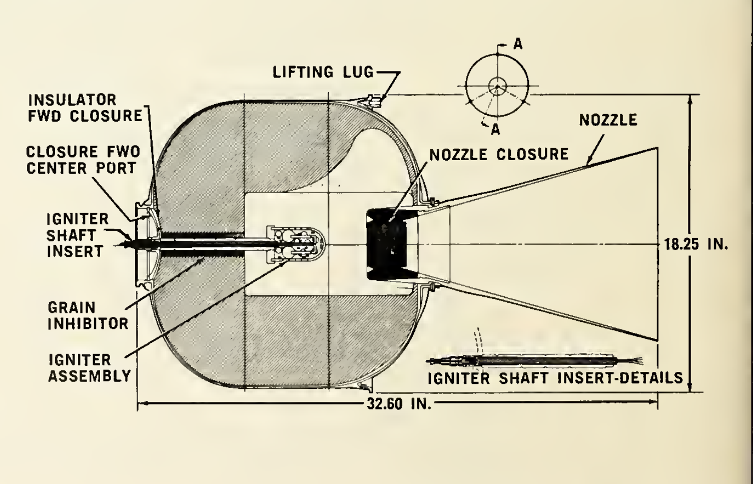
The six *Vela* satellites are positioned so that all of "near space" is continuously under surveillance. The units, according to Air Force information, can detect nuclear detonations up to and exceeding some 150 million miles. Each satellite is equipped to monitor gamma and X-rays as well as neutrons. Some of the spacecraft are equipped to differentiate between natural nuclear emissions and those created by man-made detonations. ■

LAUNCH	MOTOR IRF NO.*	DATE FIRED	PREDICTED VELOCITY FT/SEC	ACTUAL VELOCITY FT/SEC	DEVIATION FT/SEC	DEVIATION PERCENT
1	7	17 OCT 63	4346.62	4357.07	+10.4	+.24
	4	19 OCT 63	4353.13	4372.56	+19.4	+.45
2	9	16 JUL 64	4117.6	4116	−1.6	−.04
	3	18 JUL 64	4114.5	4107	−7.5	−.18
3	1	23 JUL 65	4037.6	4026.9	−10.7	−.27
	8	21 JUL 65	4060.7	4055.6	−5.1	−.13

* HERCULES BE-3

MEAN = +.07
STANDARD DEVIATION = .29

Ballistic Performance Reproducibility of the B-3 Motors in the Vela Program.



Essential components of the Hercules B-3, double-base propellant, solid rocket units.

Ames Researchers Find Mars Produces Life Forms

EXPERIMENTS carried out by the Chemical Evolution Branch of NASA's Ames Research Center Exobiology Division indicate that carbohydrates are being photochemically synthesized in the atmosphere of Mars.

The findings are yet another step in a number of experiments yielding clues as to the possible nature of the origin of life on Earth and on other places, being sought by a number of approaches at Ames.

NASA scientists have found what they think may suggest a possible pathway for the metabolism of Martian microorganisms, involving chemical rather than biological photosynthesis.

The carbohydrates synthesized by photochemical means in the laboratory in model Martian atmospheres included hexose and pentose sugars, whose yield increased with an increase in water in the system. Other important compounds identified were glucose, ribose, and deoxyribose. NASA reports that many more compounds await further analysis.

The model atmospheres used for the experiments, carried out under exobiology chief Richard S. Young, B. McCaw and Cyril Ponnamperuma, were composed of carbon dioxide, nitrogen gas and water vapor, irradiated in the ultraviolet under conditions of temperature and pressure considered to approximate those on the Martian planet.

Other studies—Primitive atmospheres which may have existed on Earth, and those which may exist or may have existed in the evolution of other planets, are also under active study at Ames. A significant achievement of recent months was the report that the Ponnamperuma group had prepared, with good yield, all five nucleotides present in DNA and RNA. Early formations of chains were also observed (M/R, Aug. 16, p. 38).

Simulation of early Earth conditions—those which may have existed some four and one half billion years ago—are being accomplished through the use of apparatus developed by the researchers at Ames.

Here, early Earth atmospheres—methane, ammonia, water vapor and small amounts of hydrogen and primitive oceans—are subjected to "lightning." This is produced by electric-discharge apparatus consisting of Tesla coils, discharged at about 100,000 volts.

The Ames scientists have found that synthesized organic materials accumulate in the "ocean" through this process and, after runs of 150 hours, some 65% of the carbon in the starting material is converted into complex organic compounds.

Another process with an effect on such mixtures which is being studied is ultraviolet light in the range below 2,000 Angstrom units.

Jupiter—The planet Jupiter is receiving special attention because it affords an opportunity to obtain knowledge of chemical evolution at low temperatures. Furthermore, it is expected to help in the understanding of the nature of the various colors seen on the planet—including its red spot.

Some Jovian conditions have been reproduced in the laboratory at Ames by Ponnamperuma and Fritz Woeller. They found that when methane or acetylene is sparked in a chamber together with ammonia, at the temperature of liquid nitrogen, a reddish-brown polymeric material is synthesized.

Upon analysis, it was revealed that this compound is formed by the reaction between cyanide and various hydrocarbon radicals.

Biological adaptation—Yet another phase of exobiological work at Ames deals with the study of Earth life forms at various extreme environmental conditions, to determine what minimal requirements may support life.

Such work not only aids in predicting life forms for various conditions and in design of life-seeking experiments, but is also important for purposes of space-vehicle sterilization.

As part of this program, recent experiments carried out by Young, Paul Deal and Oscar Whitfield dealt with the subjection of various microorganisms to diurnal freeze-thaw cycling such as might occur on Mars.

Known species of bacteria and fungi and some unidentified types which were obtained by exposing petri plates containing nutrient agar to the air outside the laboratory were put through the cycle. This included incubation at 25°C for 72 hours, after which colonies were picked from the plates and isolated in nutrient broth.

Vials containing the various colonies were then frozen at −75°C in dry ice. Each day, they were thawed at 25°C for 4½ hrs. and returned to the freezer.

Samples were taken periodically from colonies which had undergone three or more such freeze-thaw cycles.

Those cultures which continued to exhibit signs of life after three such cycles were incubated at 25°C and put into a new nutrient broth. Then the procedure was run again.

Survivors from this series were subjected to yet another series of freeze-thaw cycles—and so forth through ten or more series. Counts were taken of the survivors, and those demonstrating an increase of an order of magnitude or more were assumed to have grown under the freeze-thaw conditions.

Results to date indicate that only the non-spore-forming organisms are able to adapt to these conditions and exhibit growth. According to a NASA report, the spore-forming organisms seem to survive as spores, but they die if they vegetate and attempt to grow.

Of particular interest to the scientists is the response of four species of Clostridium, three of which are mesophiles and one a thermophile. While the latter appears to become inviable after three cycles of freeze-thaw, the others survive many cycles. Further tests will determine whether growth does occur under anaerobic conditions.

NASA points out that the implication of the apparent finding that only spore-formers are able to adapt to such conditions is extremely important for the space-vehicle sterilization program, since sterilizing for non-spore-formers is easier than for the spore formers.

Life-detection systems—Ames scientists are holding to the idea that although it is likely that carbon chemistry forms the basis for all life present elsewhere in the solar system, other forms cannot be ruled out.

The laboratory experiments show that a wide variety of organic compounds can be produced abiogenically. Thus, although the presence of complex organic molecules would suggest life, this is not the final measure.

The only evidence of life which would be sufficiently unambiguous to be acceptable to every scientific inquiry, these scientists say, would be the detection of some kind of metabolic process, and evidence of growth of a suspected life form with an increase in size and number. ■

Keeping Alive in Space: A report from General Dynamics

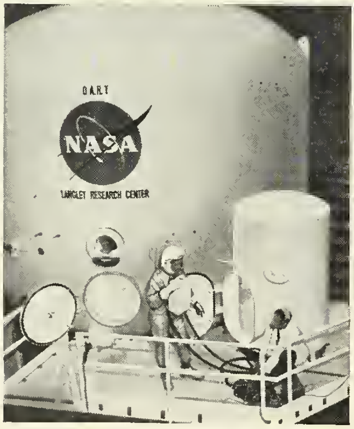
QUESTION: An astronaut in space needs 11 pounds of water and two pounds of oxygen a day to live. If you seal him into a spaceship, how long could just 11 pounds of water and two pounds of oxygen last him?

ANSWER: Forever, if necessary.

The reason, of course, is that air and water can be regenerated indefinitely, providing that a total man-machine system is properly organized.

Such a system is the heart of an experimental life-support facility which General Dynamics has recently built for the National Aeronautics and Space Administration. It is designed to take care of the basic physiological requirements of four men in a zero-gravity environment for a full year, with minimal resupply once every three months.

Regeneration is a basic fact of nature—nothing is ever really lost. The job is done by the total biosphere of the earth, its billions of cubic miles of atmosphere, its millions of miles of earth and sea, its thousands of species of animals, plants, insects and bacteria.



This sealable structure contains the prototype of a life-support system which includes facilities to maintain four men in space for a year.

Compressing even part of that system to meet the requirements of men in space is a capability that has developed only recently.

The problem—weight:

General Dynamics has been involved in the requirements of space travel for almost a generation through its development of the Atlas and Centaur space vehicles. We've been working even longer with the problem of sealed environments in the submarines we've been building since 1900.

But the submarine problem is somewhat different. Drinking water and oxygen can be produced directly from the surrounding water—which, because of its buoyancy, also makes weight a relatively minor problem.

In space, weight, including supplies, comes at an incredibly high premium.

Thirteen pounds of water and oxygen per man per day for four men for 365 days adds up to almost ten tons of water and oxygen.

One manned space platform now in development will weigh approximately 25,000 pounds. Without regeneration another 20,000 pounds of just water and air would be needed.

New water from old:

To avoid carrying such excess weight, the system General Dynamics put together for the National Aeronautics and Space Administration ties water, air and waste removal requirements into one integrated system.

Exhaled carbon dioxide, humidity, air contaminants, used washing water and urine are filtered, absorbed, heated, cooled, catalyzed and electrolyzed in a constantly operating process to create pure water and pure oxygen for reuse.

For water recovery in our system, we chose an evaporative method as the most efficient.

Excess vapor from the cabin air, used wash water and urine are collected in holding tanks and are drawn into wicks by capillary action. At the other end of the wick, water is evaporated into a stream of warmed air. The contaminants are left behind in the replaceable wicks. Condensed vapor moves through a series of filters finally to return to a central reservoir as pure water.

Regenerating air:

Air regeneration presents a more complicated problem.

Normal air is a mixture of oxygen, nitrogen, carbon dioxide, water vapor, trace gases and contaminants. Exhaled air contains less oxygen and is enriched with carbon dioxide. On earth the constant interchange between animals, atmosphere and plants consumes the carbon dioxide and the contaminants and supplies fresh oxygen.

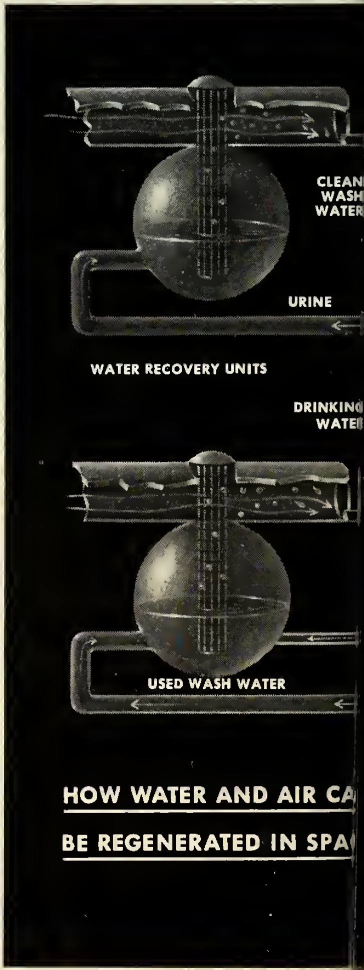
In a sealed ship the oxygen would be rapidly used up and the carbon dioxide built to a poisonous concentration.

Moreover, new contaminants are constantly being formed. At the end of some Project Mercury flights, the cabin air filter contained dozens of contaminants not present at takeoff. Some, such as ammonia, can come from ordinary chemical reactions to an astronaut's own perspiration.

Machinery now has to do the job otherwise done by nature.

How it works:

In our "spaceship," cabin air—the original mixture, plus exhaled breath, excess moisture from cooling systems and new contaminants—is continually circulated through a bank of equipment. A *dehumidifier* removes excess moisture. A



charcoal filter holds back some contaminants. A *catalytic burner* converts others. And a *separator* screens out the carbon dioxide. But the removal isn't final.

The water wrung out by the dehumidifier, for instance, is added to the central tanks for reuse. The carbon dioxide is moved to another chamber where it is mixed with hydrogen at a high temperature in the presence of a catalyst. That reaction creates water and pure carbon.

Techniques have not yet been developed to use the carbon, so it is simply blown into a storage area. But the water, collected through a porous plate, is transferred to an electrolytic cell where an electric current breaks it into hydrogen and oxygen.

The hydrogen is pumped back to fuel the previous reaction in which the water was formed. The oxygen returns to the cabin air to be breathed again.

A separate problem is presented by solid wastes. In a biological food system utilizing algae or bacteria, these wastes might fuel the growth process, but now there is no use for them. International agreements forbid the contamination of space, so they cannot be jettisoned.

Solid wastes, therefore, are dehydrated into a powdery dry residue and stored. In operating spaceships, this may serve as additional shielding against radiation or meteorites.

The work ahead:

The entire life-support system is the most advanced yet developed and does include, of course, much more than the air and water regeneration loop.

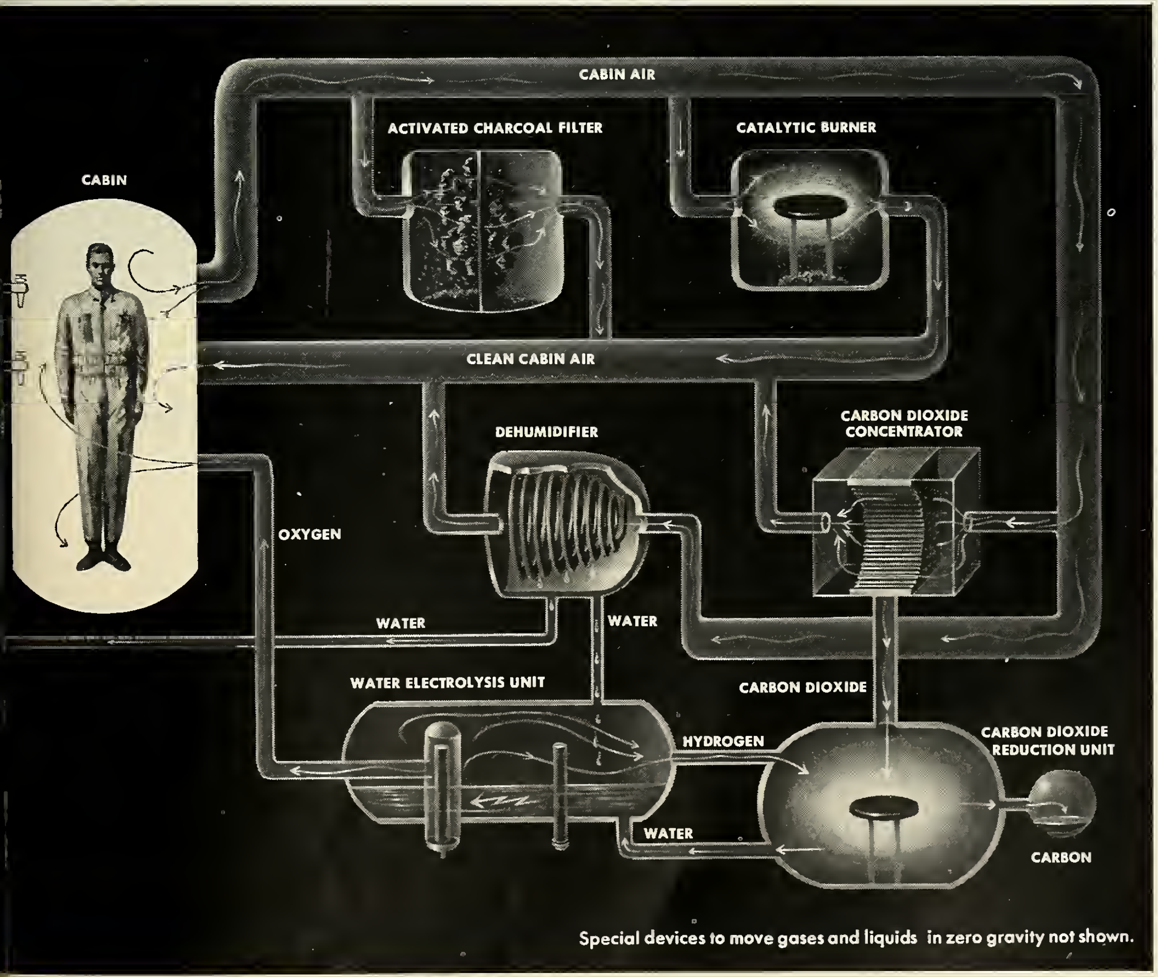
Other facets are an electricity-generating system, mechanisms to circulate gases and liquids, monitoring and control instrumentation, food preparation, storage and other facilities.

Efficient regeneration of food is not yet feasible. So dehydrated food will be carried by the spaceship and resupplied.

All in all, we think the prototype is close to what will be needed in space. But as experimental equipment it's still somewhat heavy—over two tons altogether. We expect the long period of ground testing to be conducted by the National Aeronautics and Space Administration to provide further guidelines for the design of much more compact and lighter equipment.

General Dynamics is a company of scientists, engineers and skilled workers whose interests cover every major field of technology, and who produce for defense and industry: aircraft; marine, space and missile systems; tactical support equipment; nuclear, electronic, and communication systems; and machinery, minerals and gases.

GENERAL DYNAMICS



Special devices to move gases and liquids in zero gravity not shown.

Circle No. 5 on Subscriber Service Card

Douglas researchers are looking for a "falling star" that won't burn up in the earth's atmosphere

When a space vehicle plunges back into the atmosphere, it wants to burn up like a "falling star." Douglas knows this problem goes deeper than just the surface of the spacecraft. It involves an objective study of the total system: spacecraft design, systems integration, and man-machine relationship. It calls for a balance of advanced science and practical engineering. Result? Reusable manned, scientific, and cargo spacecraft—and missile re-entry systems—plus potential savings of millions of dollars, by designing and building sophisticated aerospace systems at the lowest possible cost. **DOUGLAS** **gets things done**

MISSILE AND SPACE SYSTEMS GROUP

Titan III-C Performance Validates Solid Motor Transportation Methods

SUCCESSFUL PERFORMANCE of the 120-in. solid-motor strap-on units in the past three *Titan III-C* launches has established the feasibility of transporting large, fully loaded, solid rockets completely across the U.S.

All segments are loaded and readied at United Technology Center's propellant facility in the mountains below San Jose, Calif. These units are then shipped to Cape Kennedy for assembling into full-length boosters.

Before the first launch, UTC experts analyzed the problems in transporting the huge segments from the loading plant to both Edwards Air Force Base and Cape Kennedy. A. P. Victors of UTC says the United Aircraft Division was faced with the problem of moving oversized and overweight "freight" components large distances by both rail and truck.

After landing the 120-in. contract, Victors says UTC approached the transportation problem in two phases: development of special equipment and support systems designed to provide maximum protection to the live solid segments, and an extensive test program to insure that motor reliability would not be impaired.

Protective cocoon—The motor components are shipped in a filament-wound glass fiber container, which functions as an environmental control envelope and as a base for securing to the transporter. No shock-mitigating devices are used in the container. The method of securing consists of bolting the motor component to the base of the container and then bolting the base to the transporter. The protective cover is an enviornmental shell only. An external power source and air conditioner have been developed to provide the required environmental control.

Since there is no specific shock and vibration attenuation within the containers, the transport equipment supplies all protection. For highway transportation, a transporter consisting of a tractor, jeep and semitrailer for a total length of 80 ft., width of 11 ft. and rating of 50 tons or more is adequate. Past records showed that such a vehicle would not exceed the 3-g maximum transportation shock specified for the motor component.

Motor segment on flatcar just after being pushed by locomotive toward stationary cars.

The semitrailer was modified by strengthening the area under the container. This consists of beams and webs topped with metal plates and interface pads. This type of local support provides localized strengthening without unduly stiffening the trailer. Care was taken to keep all modifications even with or below the original semitralier bed. Leaving the bed of the trailer practically in its original state allows use of the trailer for general hauling.

The railway flatcar modification was more complex. Rail vehicles experience high shocks during train make-up, humping, and during slack runout on long freight trains. To eliminate this problem, a hydracushion pneumatic-hydraulic shock-mitigating sliding sill was used. This device reduces rail shocks to below the required 3 g's. The heavy-duty 100-ton railcar was built by the railroads specifically for hauling two motor components and their associated environmental control equipment and are owned by the railroads.

Road and rail tests—The extensive test program to prove the environments of this equipment was broken down into two phases for each mode. For the highway mode, a normal handling acceleration and strain test was conducted to determine the characteristics of the semitrailer; and then a completely instrumented 400-mi. highway transportation test was run to determine actual shock, vibration, temperature and humidity environments The rail mode included a rail impact test—to determine hydracushion performance in severe impacts—then a fully instrumented 6,000-mi. transcontinental rail test.

The purpose of the normal handling acceleration and strain tests was to demonstrate the effects of normal handling and movement by highway transporter in preparation for an actual 400-mi. road test. The transportation conditions were simulated.

The primary objectives were to demonstrate the normal strains and accelerations facing the motor components and support equipment and also to test the engineering calculations and predictions.

The instrumentation on the motor component consisted of 24 strain gages and 8 strain-gage accelerometers. Instrumentation on the container base consisted of 8 strain gages. The trailer was instrumented with 8 strain gages.

The instrumentation showed that the packaging and loading activities produced insignificant strain and acceleration. The maximum deflection measurement for the trailer bed was 1.64 in. with the 50-ton motor component.

The simulated highway movements consisted of lifting the corners of the trailer bed and pulling the trailer off 2-in. blocks. During the lifting tests, it was found the semitrailer would twist up to 4-in. before it would begin to tilt the motor components.

When dropped off the 2-in. block, the maximum accelerations were 0.21 g,X axis, 0.14 g,Y axis, and 0.13 g,Z axis. The normal handling, strains and accelerations showed no out-of-tolerance values.

Highway move detailed—The 400-mi. highway transportation test was to demonstrate the feasibility of transporting live solid-rocket motor components from the UTC Development Center near San Jose to Edwards Air Force Base. The test load consisted of a live propellant segment, (Class "B" explosive), which had 36 thermocouples cast into the grain, associated support equipment, the trailer, and a data-

Left: Shock-recording instruments are checked on flatcar. Above: Motor segment is shown during highway shipment to Edwards.

acquisition system. The loaded transporter weighed approximately 160,000 lbs. gross.

The instrumentation consisted of 117 thermocouples, 12 accelerometers, 12 strain gauges, and 2 humidity sensors. The environments were permanently recorded during actual movement. The trailer's natural frequency was obtained by driving the loaded trailer over 4-in. blocks during a deliberate stop on an incline.

The maximum acceleration on the trailer bed and container base was 0.95 g's, and on the propellant, 0.49 g's. The natural frequency of the trailer was 1.95 cps. A trailed deflection test indicated the maximum amount of trailer deflection under weight of 2.70 in.

The test showed that acceleration during highway movement was less than ⅕ of the maximum allowable 3 g's. Measured strain on the motor component was insignificant. Environments were maintained within tolerances.

Purpose of the railway car impact test was to demonstrate the effect of coupling at various speeds and to prove the adequacy of design of the rail car.

Rail test equipment—Equipment for the test consisted of one special 100-ton-capacity 20-in.-travel hydracushion underframe flatcar, five empty rail cars to be used as buffers, one switch engine, 200 ft. of level track, electric timers, stopwatches, track torpedoes, data-acquisition system mounted on a truck connected by cabling to the car-mounted components, two motor segments, and associated support gear.

Test instrumentation consisted in part of two accelographs, each with an eight-channel capacity, and two AGE shock recorders. The sensors consisted of 14 accelerometers.

The test runs consisted of accelerating the test car to various speeds and rolling it into the five standing empty buffer cars. The draft gear was extended on the buffer cars and the brakes reset after each run.

The first series of tests was run with the car fully loaded and a track weight of 247,800 lbs. The impacts occurred at 5.50, 5.65, 7.50, 9.70, and 10.30 mph. Then one motor component was removed and the car—with a track weight of 162,000 lbs.—was impacted at 5.26, 7.32, 6.11, 7.50, 8.45, and 9.70 mph. The other motor component was then removed and the car, with a track weight of 69,400 lbs., was impacted at 5.00, 7.89, and 10 mph.

The accelerometer located on the coupler sustained 25 g's on the first impact (5.50 mph). It was subsequently damaged and could not be used again. The highest accelerations attained from the tests in each axis were:

1) X axis—2.27 g, at 9.70 mph, fully loaded;
2) Y axis—2.90 g, at 7.32 mph, partially loaded;
3) Z axis—0.94 g, at 7.50 mph, partially loaded.

Maximum draft gear sill travel was 18.5 in. at impact of 10.30 mph. Maximum buffer car movement along the track was 192 in. at impact speed of 9.70 mph.

The results showed all environments were below maximum allowable. The motor component maximum acceleration was almost 1 g less than maximum on the car deck.

Cross-country rail run—The purpose of the transcontinental rail test was to prove the safety of transportation and obtain reliable data on actual environments. The test equipment consisted of the loaded 100-ton special flatcar, a 70-ft. railroad baggage car to house the data-acquisition system, and a personnel railcar. The instrumentation was essentially the same as that used for the 400-mi. highway test.

The test unit proceeded from its origin railhead near San Jose to Los Angeles by special train, making three braking stops at speeds of 15, 25, and 35 mph. From Los Angeles, the test cars were moved in regular freight train service and normal operating schedules. The route went through El Paso, New Orleans then to Birmingham, Ala., and down to Jacksonville, Fla. The return shipment went from Jacksonville to Birmingham to Kansas City, across to Salt Lake City and back to San Jose.

Instrumentation records were cross-referenced to include oscillograph acceleration records with train speed tapes, geographic location, time and mile posts, location of test car from engine, and Bristol recorder temperature records with oscillograph records of wind direction, wind velocity, train speed, geographic location, and time-mile posts.

The highest accelerations were 13 g's on the test flatcar coupler in the X axis, 1.8 g's on the test flatcar bed in the Y axis and 1.8 g's on the motor component in the X axis. These were the result of inherent slack built into the coupling system of each car. While the slack per car is small, the total slack for an entire train can be quite large and produce a "whip" effect especially noticeable when traversing rolling terrain and during dynamic braking. Train lengths during the test varied from 16 cars with a total weight of 193 tons to 185 cars with a total weight of 8,946 tons. By adding the slack produced per coupler the engine would travel 61 ft., 8 in. to move the last of the 185 cars.

The frequency range was: 1) Z axis, 2 to 7 cps; 2) X axis, 5 to 10 cps; and 3) Y axis, 5 to 20 cps. In addition, a frequency of 40 to 100 cps was imposed upon the basic forcing frequencies. ■

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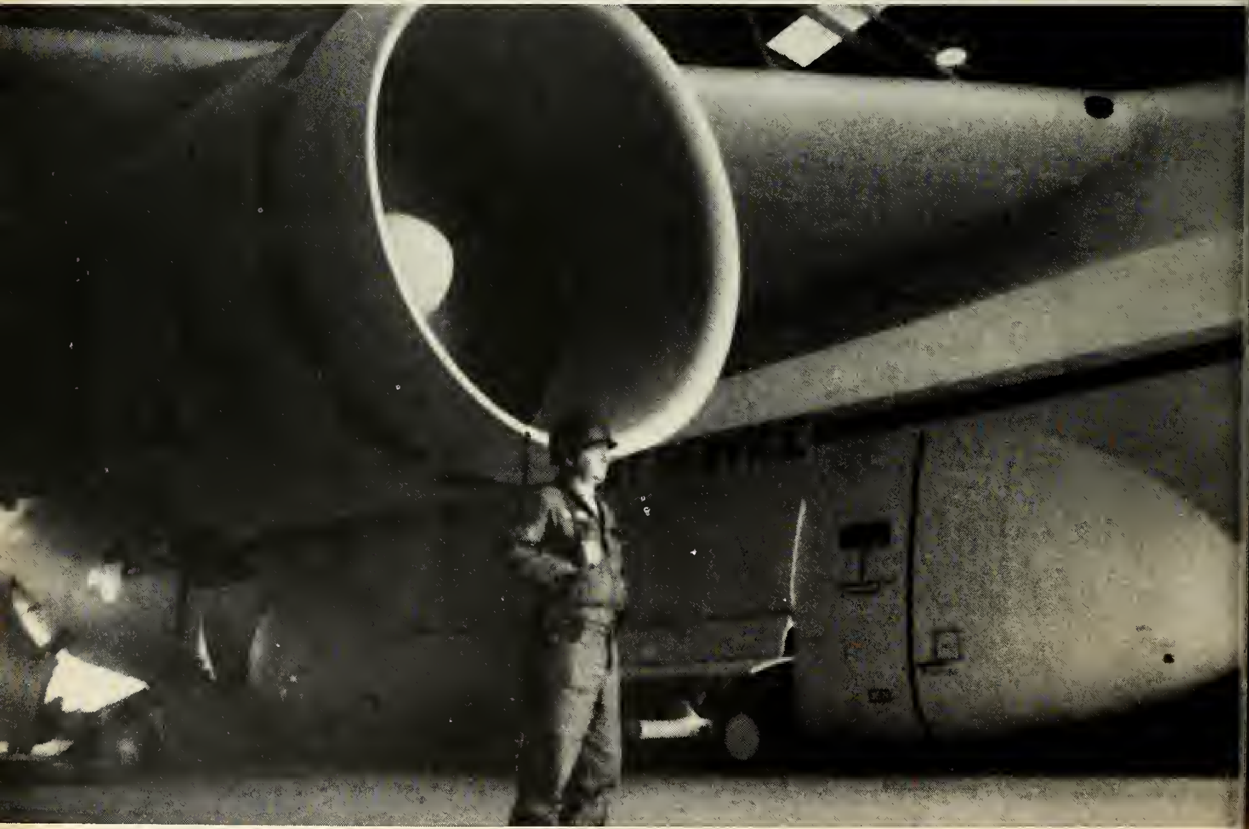

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Mariner Venus Craft Lacks Power for TV

Payload changes force JPL to buy new data automation system; planned experiments

PASADENA, CALIF.—Electric power limitations on the 1967 *Mariner* Venus spacecraft will prevent inclusion of a television system. Revamping of the experimental payload will require the Jet Propulsion Laboratory to procure a new data automation system using integrated circuits.

Prime aim of the mission is investigation of the Venutian atmosphere.

Dan Schneiderman, JPL mission project manager, told MISSILES AND ROCKETS a decision on the experimental payload to fly by Venus in 1967 would be reached by Feb. 14. The expected configuration will include:

—A radio frequency occultation experiment carried out at three frequencies. The S-band signal will be observed during occultation by one group of experimenters. A second group will transmit a 50-mc signal to an onboard receiver and receive a telemetered indication of the reception at 450 mc. This is the same experiment as is carried on *Pioneer,* but will use a different antenna.

—An ultraviolet photometer to investigate the upper atmosphere of Venus. This is the instrument that was taken off of *Mariner 4* because of the interference it caused with other systems. "It's been tested long enough so we don't think it will arc over," said Schneiderman.

—A trapped radiation detector to search for belts of radiation similar to the Van Allen belts around the Earth.

—A plasma probe to investigate interplanetary plasma and to search for discontinuities in the plasma in the vicinity of the planet.

—A magnetometer to investigate the interplanetary and the Venutian magnetic fields.

—Celestial mechanics by accurate trajectory analysis.

The power limitation comes not from the solar panels but from the onboard power conditioning units—boost regulators and power inverters.

Off-shelf philosophy—The spacecraft to be used is *Mariner 5,* a complete spare spacecraft that was held in readiness for the *Mariner* Mars mission.

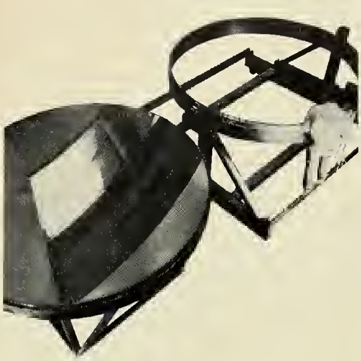
JPL's philosophy is that spares must be as well qualified as a flight unit. And, since the chief qualification is testing of the complete spacecraft system, the spare itself has to be a complete system.

"There is a lot of value in this mission besides going to Venus, said Schneiderman. "For example, how has it *(Mariner 5)* survived storage? That is a very valuable piece of information."

It will indicate whether it is feasible to build up a stock of spacecraft for off-the-shelf use as required, and will give further data on the reliability of *Mariner* systems.

A second feature of the Venus mission is that it will be leaving the vicinity of Earth just as *Mariner 4* is returning from its long journey past Mars. The *Mariner* office at JPL will have to devise ways of keeping track of the performance of two spacecraft. This is expected to be operational experience of value to the *Voyager* team.

At present, preparations are under way to test *Mariner 5* as a system. It has been kept in nitrogen storage and will first have to be purged. Once its condition after storage has been determined, it will be disassembled for subsystem



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testing. "This must be done carefully," emphasized Schneiderman. "Remember, we expect to fly most of this spacecraft."

The JPL policy of having a spare spacecraft will in fact be modified for this shot. Instead of a flight spacecraft, a spares qualification unit will be used. This will be a non-flight assembly on which essential subsystem spares, which must be flight-qualified, will be hung for tests.

Mission parameters—The launch vehicle will be an *Atlas-Agena*, using the same type of shroud as the *Lunar Orbiter*. This in turn has been adapted from the second *Mariner* Mars launch vehicle shroud. The aim is to achieve a 21-day launch window, from late May to mid-June, 1967, for the 575-lb. spacecraft.

The arrival date at Venus, which is held constant independent of launch date because it fixes encounter geometry, will be in the period Oct. 1-14, 1967. The 14th appears to be the best day, and it is coincidental that the two previous *Mariner* planetary encounters have been on the 14th of the month. The arrival date was scheduled to be fixed by Feb. 14.

The spacecraft's trajectory is expected to pass within 3,000 mi. of the planet's surface. *Mariner* will encounter the planet on the dark side but will quickly pass over the terminator and swing over the sunlit surface.

The closeness of the approach means that the scan platform carried by *Mariner 4* may not be needed. The planet will loom very large in front of the spacecraft and there is no indication that the instruments should be pointed to any particular point on its disc.

As atmospheric measurements are the prime mission, the occultation experiment decides the trajectory. It does in fact put more constraints on the trajectory than the Mars shot, but the achievable accuracy of the flight path is expected to be higher.

The trajectory and the Earth-Venus motions are such that a fixed high-gain antenna can be used, and Schneiderman believes it will meet the project's requirements. The real question is what shape of beam the antenna should have at occultation, and the answer to this may mean that the antenna design has to be modified.

Current problems with the dual-frequency RF experiment on *Pioneer*, which probably will be used on *Mariner 5* for the occultation, have been attributed to antenna design.

Power shortage—One effect of flying the more complex radio occultation experiment on *Mariner 5* is that as it passes out of sight behind the planet it is receiving information from Earth and retransmitting it. At the same time it should be taking television pictures, if these are to be obtained. In fact, most of the TV pictures would be taken during the period of occultation. The net effect is that the requirements to record data and to use power are considerably greater than those obtaining during *Mariner 4's* encounter with Mars. The power required exceeds by 10 watts the power available.

There does not appear to be sufficient money and manpower available in the project to resolve this problem, so the television experiment is likely to be dropped. If it is, all those experiments lower in priority will also be dropped. These are an optical occultation experiment, a cosmic ray telescope, and a cosmic dust detector.

Although the power conditioning system cannot deliver the output that a TV camera would call for, the solar panels will be able to produce plenty of power. The chief problem with these is that they will get too hot. Solder on them is likely to melt a month after encounter as the spacecraft gets closer to the Sun. To keep the heat radiated from the panels into the spacecraft as low as possible, an inner area of cells on each of the four panels will be removed. The panel structure will cover the same area as on *Mariner 4*, but because it will be closer to the Sun fewer solar cells are required.

The panels will be put out on contract, as a new set will have to be built. For Mars, a high-voltage, low-current system was developed. The reverse will be used at Venus—low-voltage, high-current. Also, the insulation used in the Mars panels may not be able to withstand the temperatures near Venus.

Other areas in which contracts will be placed with industry include the telecommunications equipment and data automation system.

The DAS is the major system to go out to industry, and will be completely rebuilt.

It will make use of integrated circuits instead of the devices made by dotpellet technique for use on *Mariner 4*. For reliability JPL would have preferred to go to what it calls utility modules, which is a form of the cordwood-welded technique. However, this would have been so bulky as to call for redesign of the system. On the time scale available, this was considered a bigger risk than going to integrated circuits.

The fact that integrated circuits draw more power than conventional circuits has added to the spacecraft's power problems.

JPL will institute an engineering change system to keep a tight rein on modifications to the spacecraft.

The attitude-control vanes at the ends of the solar panels are tentatively scheduled to come off, but it may turn out to be less bother to leave them on. The same cold-gas attitude control system will be used, and the same mid-course propulsion system.

Organizational plans—Schneiderman said that the in-house organization the JPL has set up to handle the *Mariner* Venus project is a mixture of some of the more advanced arrangements set up for *Voyager* with what has been done in the past.

As assistant project manager, Schneiderman will have Ted Parker. The management system then breaks down as follows:

Project administration, including documentation and the engineering change system, will be managed by David E. Shaw.

Resources, including such things as fiscal analyses, will be managed by Miss Frances Fairfield.

Procurement liaison functions, including expediting and liaison with contractors, will be managed by Lawrence T. White.

Launch vehicle manager will be appointed by NASA-Lewis.

Mission operations manager, who handles the team that flies the spacecraft, has not been appointed yet. This is a difficult position to fill because of lack of people with such experience.

Trajectory and data analysis manager is also to be appointed. At present Dr. Renzetti is temporarily in this position.

Mission analysis, chiefly trajectory analysis, will be managed by Mr. Norman Haynes.

Project scientist is Dr. Conway Snyder of JPL.

The *Mariner* '67 project actually has a staff of 12 at present—Schneiderman, Shaw, Fairfield, Wolfe, Parker, Snyder, and the mission operations manager and five secretaries.

These are supported by the permanent divisions at JPL, through project representatives.

White is from the procurement division. Responsibility for scientific instruments and their integration into the spacecraft rests with Mr. John Paulson of the space science division.

Thomas C. Sorenson is the project representative for the telecommunications division and is responsible for transmitting, receiving, command, and data encoding subsystems.

Paul Seminara of the guidance and control division has responsibility for the auto-pilot, attitude control system, and the solar power and power conditioning systems.

All these are paid for by the project, but their administration and facilities are not provided by the *Mariner* office. All the technical divisions would in fact be *Voyager* administration. ■

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NASA, AF Enthusiastic About Solar-Electric Powerplants

Los Angeles—A 500- to 800-lb. precursor probe could be launched to Jupiter by means of an *Atlas-Centaur,* or a 2,000-lb. *Voyager* spacecraft bus could be sent to the same planet using a *Titan III-C* if further work on solar-electric propulsion confirms the optimistic results of a Joint NASA/Air Force study just completed.

These show that there is a feasible way of getting 5 to 50 kw of power from a solar cell array, Peter N. Haurlan, manager of future projects at the Jet Propulsion Laboratory, told the 1966 Winter Convention on Aerospace and Electronic Systems here.

"If this is so, then we probably have a whole new era opening up for us in deep-space probes," he added.

Haurlan described the precursor probe concept for planetary missions, which with *Mariner* and *Voyager* spacecraft would provide the basic equipment for unmanned interplanetary exploration for the next two decades. By using these three spacecraft for all missions, maximum cost-effectiveness will be realized, said Haurlan, "and this is the criterion for the next few years."

Precursor probe—Haurlan told the meeting that the *Mariner* spacecraft would have a very wide application through the 1970's and maybe even through 1980. It will be suitable as a comet, asteroid and *Mercury* probe. *Voyager* Mars hardware will be applicable to all other planets, he said. The orbiter portion can function as a substantial fly-by spacecraft for Jupiter and the outer planets.

However, these will not be the only two spacecraft used, said Haurlan. "We think we have hit on a low-cost candidate—the precursor probe" (M/R, Nov. 29, p. 105). This has as its scientific objective the minimum amount of instrumentation that will provide useful information—chiefly fields and particle experiments. "If the cost is low compared with *Mariner,* then we have something we could use certainly through the 70's and maybe through the 80's," said Haurlan.

Currently JPL has a contract with TRW Systems Group to examine whether such a spacecraft could accommodate a television camera.

"In a few months we expect to come up with a preferred concept," said Haurlan. The work done so far shows that the individual pieces of hardware required for such a spacecraft, even if it carried some sort of television system, are "not much beyond the state of the art."

Kick stage added—For the 500- to 800-lb. probe under study, minimum energy trajectories to the near planets can be used. However, for flights to the outer planets or to Mercury, an additional kick stage using fluorine would have to be developed. This would put 800 lbs. out to Jupiter and 600 lbs. out to Saturn. The latter mission would take six years.

A means of reducing mission time and launch energy requirements is available in the planetary swing-by technique, said Haurlan. Studies have shown that Earth-based guidance is sufficiently accurate (150-km RMS dispersion at Venus) for a swing-by mission to Mercury.

"We have not yet looked at the guidance requirements for Jupiter, but we expect them to be about the same," said Haurlan. A Jupiter swing-by reduces mission time to Saturn to four years and that to Pluto from 46 to 9 years. Opportunities for Venus swing-by missions are good from now until 1973 and will reoccur in the early 1980's. Planetary positions are good for Jupiter fly-bys in the 1976-80 period.

Solar electric propulsion—A program based on a single booster that makes use of a new third stage is viewed with some skepticism by industry and there is considerable motivation for avoiding the kick-stage requirement.

Haurlan suggested that the most likely solution was use of solar electric propulsion (M/R, Nov. 8, p. 40). A Boeing study has shown that 5- to 50-kw solar cell arrays are feasible "using reasonably standard, almost conservative approaches," said Haurlan. Systems studies of electrically propelled spacecraft using these arrays, carried out at Electro-Optical Systems, Inc., and Hughes Aircraft Co., show that this form of propulsion is competitive if a power-propulsion system weight of 100 lbs. can be achieved. In fact, 75 lbs./kw appears easily available.

"It looks as if *Atlas-Centaur* without a kick stage will be enough to get the 500- to 800-lb. probes out to Jupiter, said Haurlan, if solar electric propulsion is used.

The next step, he added, is to go to full-scale testing of these very large solar cell arrays. Bonding techniques have been demonstrated and scale models showing deployment techniques have been built.

Some life tests on ion engines have been carried out for periods of thousands of hours. These will have to be considerably extended—up to 15,000 hrs. "But we believe there are no serious problems in the engines," said Haurlan.

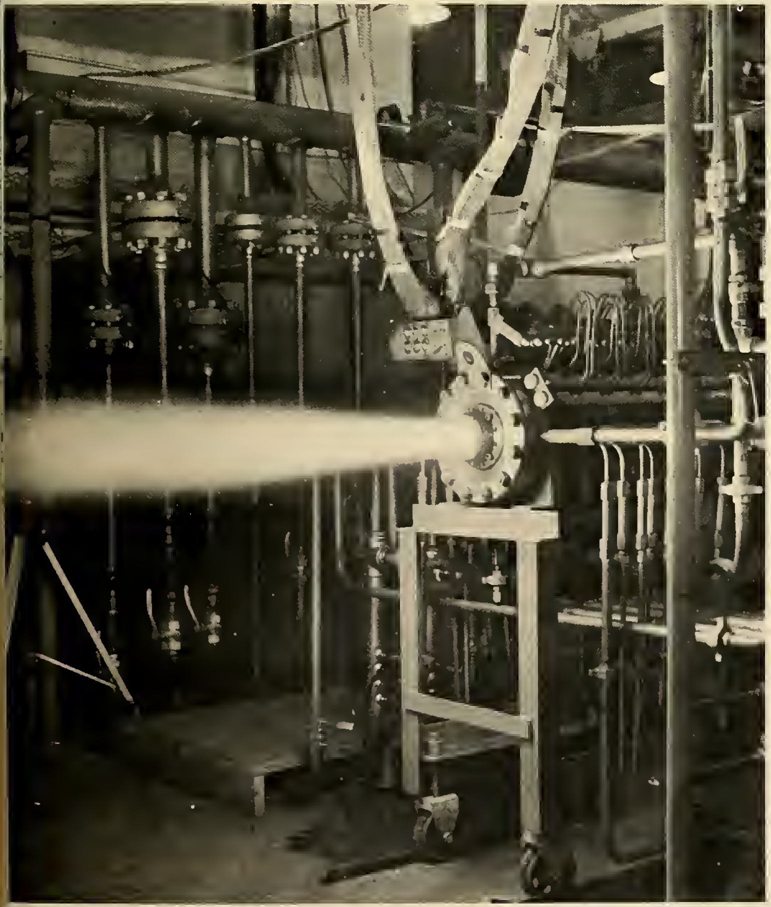
Optimization of propulsion system design for specific missions is needed. Testing of engines in clusters is also required. The power conditioning system requires evaluation and ion exhaust impingement on the solar panels has to be analyzed further.

Software techniques also have to be developed to see if it is feasible to combine solar electric propulsion, with its low approach velocity, with planet swing-by techniques.

If these two techniques can be combined, a precursor probe for exploring the outer planets in the 70's and 80's will be available. ■

Westinghouse Simulates Re-entry Conditions

White hot jet of air from this "arc heater" will be funneled into a wind tunnel at the Air Force Arnold Engineering Development Center, Tullahoma, Tenn., to simulate conditions of hypersonic re-entry experienced by missiles and spacecraft. Heater, being developed by Westinghouse Electric Corp., is said to be the most powerful ever built. It will heat air to 13,000°F—some 2,000°F hotter than Sun surface temperatures. It is being shipped to the Air Force this week.



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Mergers and Acquisitions

Merger activity in the aerospace-aircraft industry is expected to increase during 1966, a financial consulting firm has predicted. W. T. Grimm & Co., Chicago consultants specializing in corporate acquisitions, estimates 25 to 30 aerospace-aircraft mergers during 1966, up from 24 in 1965. Of the 1965 total, cash deals accounted for 75% of the total, stock deals for about 17% and cash-stock combinations for the remainder. Average price/earnings ratio paid for aerospace-aircraft firms was 14.6. . . . *General Precision Equipment Corp., Tarrytown, N.Y., and Controls Co. of America, Melrose Park, Ill., are considering a merger. The proposal is subject to stockholder approval by both firms. The transaction has been valued at more than $43 million in stock.* . . . Avnet, Inc., Los Angeles, has purchased Busacker Electronic Equipment Co., Inc., Houston, and its subsidiary, Contact Electronics, Inc., Dallas. . . . *General Transducer Co., Santa Clara, Calif., has purchased the temperature-measuring and controlling instrument line of Royco Instruments, Inc., Menlo Park, Calif.* . . . Allied Research Associates, Inc., Concord, Mass., has acquired the assets of the Aerospace Div. of Aeronca Manufacturing Corp., located at Friendship International Airport, Baltimore, Md.

New Activities

International Telephone & Telegraph Corp. has formed a new Controls and Instruments Div. in Glendale, Calif. The new division consolidates the General Controls, Barton Instrument Corp., Hammel-Dahl and Henze Valve Service divisions of ITT. James V. Lester will serve as chief executive of the new division. . . . *EG&G International, Inc., has been formed in Bedford, Mass., as a wholly owned subsidiary of Edgerton, Germeshausen & Grier, Inc., Boston. The new firm assumes from the parent company the manufacturing, marketing and field operations responsibilities for the firm's oceanographic-geophysical products and field surveying capabilities.* . . . Wellman Bronze & Aluminum Co., Bay City, Mich., has changed its name to Wellman Dynamics Corp.

International

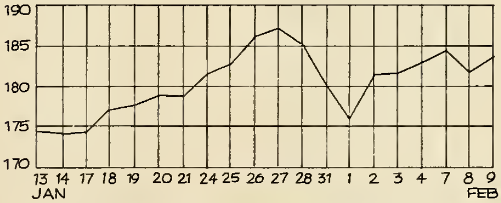
Computer Control Co., Inc., Framingham, Mass., has named Kyokuto Boeki Kaisha, Ltd., Tokyo, Japan, to market, service and install its computers and digital products in Japan. . . . *Spaulding Fibre Co., Inc., Tonawanda, N.Y., has acquired the British Vulcanized Fibre Co., Ltd., Manchester, England. It will be operated as a subsidiary of Spaulding's British company, Spaulding, Ltd.* . . . Data Technology Corp., Mountain View, Calif., and Tek Elec of Cite des Bruyeres, Sevres, France, have signed an agreement for the sale and manufacture of digital voltmeters in France. . . . *P. R. Mallory & Co., Inc., Indianapolis, Ind., and Mitsubishi Metal Mining Co., Ltd., have formed a joint company in Japan. The firm will market the Mallory line of metallurgical products.*

Facility Expansions

Radiation Systems, Inc., Alexandria, Va., plans to move to a new 60,000-sq.-ft. facility in the Westgate Research Park, McLean, Va. The new building will house research, development and manufacturing operations. . . . *NASA's Ames Research Center, Moffett Field, Calif., will begin construction of a facility to house satellite and interplanctary space probe projects. The 63,450-sq.-ft. facility is scheduled for completion in November.* . . . Raytheon Co. has completed a 20,000-sq.-ft. addition to its Industrial Operation plant at South Norwalk, Conn. . . . *The Naval Ordnance Test Station, China Lake, Calif., has started construction of a $330,000 facility to consolidate warhead research and development activities.* . . . Gardner Cryogenics Corp., Bethlehem, Pa., is constructing a 30,000-sq.-ft. headquarters building. Completion is scheduled for May. Production of liquid helium will continue at facilities in Hightstown, N.J., and El Segundo, Calif. The firm is also building a joint plant with Alamo Chemical Co. near Elkhart, Kan.

Missile/Space Stock Index

The Missile/Space Weighted Stock Index reflected a surge of selling of defense stocks Feb. 8 with the reports that peace feelers had been made by North Vietnam. However, it rose again as prospects of settling the Vietnam situation again seemed remote. . . . *LTV Aerospace Corp. stockholders approved a 2½-for-1 stock split of all common stock and reclassification of common shares held by the parent company into a new non-divided class B common stock (M/R, Feb. 7, p. 37). LTV also will file a registration statement with the Securities Exchange Commission in the near future in connection with a proposed public offering of 500,000 shares of common stock after the split. Stockholders will receive an additional three shares for each two held of record Feb. 14.* . . . General Precision has set May 18 for its stockholders meeting and has announced that votes will be taken on the proposed merger of Controls Corp. of America into General Precision Equipment Corp.



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
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IMMEDIATE OPENINGS IN SENSOR SYSTEMS TECHNOLOGY

MITRE works on the frontier of large-scale system design. We design and engineer information, sensor, command, control and communications systems and develop new techniques in these areas to advance the general technology.

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MITRE is located in pleasant suburban Boston. If you have two or more years' experience and a degree in electronics, physics or mathematics, write in confidence to: Vice President, Technical Operations, The MITRE Corporation, P. O. Box 208, Dept. G, Bedford, Mass.

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contracts

AIR FORCE

$5,595,960—**Sperry Rand Corp.**, Charlottesville, Va., for manufacture of radar sets.

$4,955,185—**Aerojet-General Corp.**, Sacramento, Calif., to continue manufacture of storable liquid-propellant rocket engines.

$4,695,000—**IIT Research Institute**, Chicago, increment to existing contract for operation of an electromagnetic analysis center for space studies with work to be done at Annapolis, Md.

$3,500,000—**ITT Federal Laboratories**, Nutley, N.J., to install and test electronic equipment at various overseas locations.

$2,600,000—**Hughes Aircraft Co.**, Culver City, Calif., increment to existing contract for work on an air-to-surface missile guidance program.

$2,000,000—**Avco Corp.**, Wilmington, Mass., increment to existing contract for re-entry vehicle technology.

$1,858,008—**Olin Mathieson Chemical Corp.**, New York City, for rocket propellant.

$1,180,000—**Thiokol Chemical Corp.**, Bristol, Pa., increment to contract for R&D stage I *Minuteman* motors.

$800,000—**Litton Systems**, Westrex Communication Div., New Rochelle, N.Y., for joint airborne communications center/command post.

$44,600—**Westinghouse Electric Corp.**, Defense and Space Center, Baltimore, for development of *SAM* deception system.

$44,412—**Hughes Research Laboratories**, Malibu, Calif., for test and analysis of a thrust stand.

$37,920—**TRW Systems Group**, Redondo Beach, Calif., for analytical research and satellite payload design.

$36,000—**Radio Corp. of America**, New York City, per month rental contract with purchase option for replacement of electronic data processing equipment.

ARMY

$8,000,000—**Philco Corp.**, Aeronutronic Div., Newport Beach, Calif., for continuation of engineering, design and development efforts and fabrication of engineering prototypes of fire units in support of the *Chaparral* air defense system.

$7,159,798—**Global Associates**, Oakland, Calif., contract modifications for logistics/base support for Kwajalein test site, for additional effort and extension of contract period.

$6,693,598—**Hercules Powder Co.**, Radford Va., for continued manufacture of propellants and explosives.

$3,480,000—**Medico Industries**, Pittston, Pa., for metal parts for 2.75-in. rockets.

$348,000—**Bunker-Ramo Corp.**, Silver Spring, Md., to automate a portion of the Army budget system.

$216,280—**Raytheon Co.**, Andover, Mass., in two contracts for *Hawk* system repair parts. Also $33,800 for *Hawk* missile system reconditioning assemblies.

$116,042—**Babcock Aerospace, Inc.**, Costa Mesa, Calif., for digital receiver-decoder systems.

$96,950—**Canadian Commercial Corp.**, Ottawa, Canada, for study and analysis of propellant for use in meteorological rocket program.

NAVY

$20,520,000—**Westinghouse Electric Corp.**, Baltimore, for classified development work in connection with *Polaris* program.

$13,498,698—**Westinghouse Electric Corp.**, Baltimore, modification to existing contract for airborne radar sets.

$10,196,775—**Vitro Corp. of America**, Silver Spring, Md., for engineering services for *Terrier*, *Tartar* and *Talos* missile systems.

$7,691,939—**Litton Systems**, Woodland Hills, Calif., for airborne navigation computer set components.

$3,543,900—**Otis Elevator Co.**, Stamford, Conn., to make trainers for the *Sheridan-Shillelagh* weapons system.

$493,298—**Aerojet-General Corp.**, Solid Rocket Plant, Sacramento, Calif., for long lead-time effort for procurement of Mk 27 mod 2 rocket motors and igniters for *Tartar* missile system.

$407,061—**Atlantic Research Corp.**, Alexandria, Va., contract extension for spectrum signature measurements and other tests concerned with radio frequency interference.

$64,389—**Aerochem Research Laboratories**, South Brunswick, N.J., for R&D program directed toward ionization and radar interference effects in rocket propellant exhausts with the ultimate goal of reducing and predicting electromagnetic wave attenuation.

$56,381—**FMC Corp.**, Northern Ordnance Div., Minneapolis, Minn., for guided missile launching system used on *Tartar* missile.

$30,000—**Motorola, Inc.**, Military Electronics Div., Scottsdale, Ariz., to investigate and analyze *Sidewinder* IC Mk 12 guidance and control.

NASA

$630,000—**Spacelabs, Inc.**, Van Nuys, Calif., from Manned Spacecraft Center for flight-qualified medical experiment equipment for the *Apollo* spacecraft.

$592,471—**Douglas Aircraft Co.**, Santa Monica, Calif., from Headquarters for development and demonstration of criteria for liquid fluorine feed system components. Also, $115,000 from Goddard Space Flight Center for development of technical evaluation report for structural analysis.

$349,672—**Aerojet-General Corp.**, Sacramento, Calif., from Manned Spacecraft Center for service propulsion engineer components.

$240,000—**Collins Radio Co.**, Cedar Rapids, Iowa, from Manned Spacecraft Center for S-band power amplifier.

$225,939—**University of New Mexico**, Albuquerque, N.M., from Goddard Space Flight Center for experiment for *Orbiting Solar Observatory-G* on high-energy neutron flux in space.

$148,470—**TRW** Systems Group, Redondo Beach, Calif., from Lewis Research Center for investigation of resin systems for improved ablative materials.

$99,481—**Rocket Research Corp.**, Seattle, Wash., from Goddard Space Flight Center for the development and fabrication of the anchored *Interplanetary Monitoring Probe-E* attitude control thruster system.

$70,833—**Rutgers University**, New Brunswick, N.J., from Goddard Space Flight Center for *Orbiting Solar Observatory-G* experiment, determination for brightness, polarization and ellipticity of the zodiacal light.

$66,521—**Bell Aerospace Corp.**, Bell Aerosystems Div., Buffalo, N.Y., from Headquarters for synthesis for spacecraft structures study.

$53,399—**Westinghouse Electric Corp.**, Research Laboratories, Pittsburgh, Pa., from Lewis Research Center for study of electron collisions in metal vapors.

INDUSTRY

$2,500,000—**Chicago Bridge and Iron Co.**, Chicago, from **Martin Co.**, Baltimore, for design and construction of a space simulator facility at Martin's Denver Div.

$700,000—**Dynamics Corp. of America**, Los Angeles, from **Page Communications Engineers, Inc.**, Washington, D.C., for FM microwave communications equipment for four transportable ground relay stations for the satellite communications system linking U.S., Australia, and Hawaii in the *Apollo* program.

$250,000—**Vitro Corp. of America**, Vitro Electronics, Silver Spring, Md., from **Electronic Specialty Co.**, Los Angeles, two contracts for tracking and data receivers, diversity combiners, predetection converters and spectrum display units for use on the Pacific Missile Range. Also, $100,000 from **Dynatronics, Inc.**, Orlando, Fla., for conical scan tracking receivers for use on PMR.

$190,000—**H. C. Smith Construction Co.**, Compton, Calif., from **Boeing Co.**, Seattle, Wash., to assist in modification of *Minuteman* standby power systems at sites near Whiteman AFB, Mo.

$115,000—**Space Ordnance Systems, Inc.**, El Segundo, Calif., from **North American Aviation, Inc.**, Space and Information Systems Div., Downey, Calif., for a separation system for use in the emergency escape system of the *Apollo* spacecraft.

$75,000—**C. G. Hokanson Co.**, Los Angeles, from **Boeing Co.**, Seattle, Wash., for water chillers for use in *Minuteman* environmental control system.

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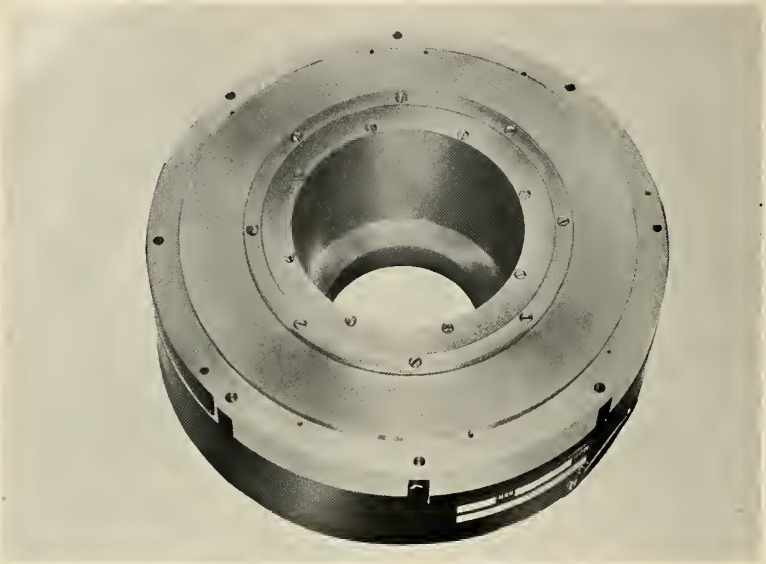

New Product of the Week: Optical Encoder

A 19-bit natural encoder with accuracy of better than ± 1 bit has been announced by Sequential Electronic Systems, Inc.

The binary optical encoder has an 8-in.-dia. housing with self-contained, fully integrated electronic circuitry; resolution is 2.47 arc/sec.

The unit generates digital word representations of absolute angular position. Representation is directly obtained and presented in a natural binary format that can be continuously displayed or interrogated by low-level electrical pulses.

Bit accuracies have been calibrated to a peak maximum placement error of 0.33 arc/sec. from one bit to any other.

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Peak Load Indicator

Seegers Instrument Co. is marketing a pressure transfer standard peak load indicator with an accuracy of within 0.1% FS on initial readings and 0.05% on repeat readings.

The instrument uses a low-inertia movement system which reduces reading errors due to inertia, stiction, friction and vibration, the firm says. The indicator has a back mirror to eliminate reading errors caused by parallax. Errors caused by changes in perpendicularity, temperature, gravity or buoyancy are corrected by means of a zero reference adjust.

The device is available for pneumatic or hydraulic applications, the company says.

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A servo control unit designed to provide close amplitude control of current, voltage, sound pressure and vibration has been anounced by Dranetz Engineering Laboratories, Inc.

Model 501 is used for d-c and c-w sinusoidal signals in the 100-cps to 100-kc frequency range and with pulsed c-w when provided with an external peak detector. Time variant level control or amplitude modulation of a-c signals can be provided when the unit is used with function generators or programmers.

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Astrodata, Inc., is marketing a PCM signal simulator, the Model 600-103.

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It's an Ill Wind . . .

LANDING OF THE SOVIET *Luna 9* on the Moon has been, ironically enough, a shot in the arm for the U.S. lunar landing program. The spectacular photographs returned by the Russian spacecraft have ended any doubt that the lunar surface can support the weight of *Apollo's* Lunar Excursion Module.

There was not any substantial doubt in this regard, certainly not among the *Apollo* team, but the visible evidence of a solid surface has laid to rest any concern over a deep dust layer or "meringue pie" structure covering the entire lunar surface.

The quickening of confidence as a result of this is evident. It is a fact that the Soviet success has contributed as much to the U.S. *Apollo* program as to the Russians' own lunar effort. The major benefit hoped for from the still-grounded *Surveyor* project was just such confirmation as provided by the *Luna 9* photographs.

It is unfortunate that an ill-conceived U.S. project thus was overshadowed by a determined and finally successful Soviet effort. In the long run, however, the data remain more important than the nationality of those initially obtaining them.

That the Soviet *Luna* project would culminate in success before the initial *Surveyor* flight was almost a foregone conclusion. We pointed out many weeks ago in the pages of this magazine that the step-by-step Soviet manned lunar program was concentrated on this project as its next objective. The Russians now can move on to their next step, which is quite likely to be the accomplishment of rendezvous.

Soviet Cosmonaut Gherman Titov has indicated to the press that the Russians also may be planning to land a dog or dogs on the Moon prior to a manned landing. It is hard to see what could be gained by this, other than a dubious propaganda victory. The ability of man to survive the duration of a lunar journey through space already has been shown in the *Gemini* program, and tests of the life support systems for such a flight can be carried out in Earth orbit.

As was also quite predictable, the *Luna 9* photographs have completely outdated the *Ranger* photos obtained at such cost by the U.S. They also have done what the expensive *Ranger* photographs did not, and could not do—confirmed the solidity of the lunar surface. Despite all the talk of advances in scientific knowledge made possible by the *Ranger* photographs, whatever knowledge was thus obtained is now as dead as the Moon itself. *Luna 9* has ended the debate about whatever it was that the *Ranger* photographs suggested to the eye of the scientific beholder—dust, rock, or meringue.

It should by now be evident that expenditure of vast sums to obtain scanty scientific information on the lunar surface is folly—the manned expedition will provide it in abundance and detail in a few short years. Objective of the unmanned probes to the Moon should be to obtain the engineering data necessary to *Apollo*—and nothing more. Imposition of scientific tasks on these basic requirements only increases the risk that a mission may be unsuccessful.

Yet we find Dr. William Pickering, director of Jet Propulsion Laboratory, saying: "It is to be hoped that scientific data from *Surveyor* will complement that received from the Soviet spacecraft and provide us with not only a detailed description of the surface of the Moon but also a far better picture of the evolution of our solar system."

THERE IS NO SENSE whatever in viewing *Surveyor* as an attempt to obtain a picture of the evolution of our solar system. That information, if it is there, will come out in far greater detail in the *Apollo* program. To burden *Surveyor* with such a role is unnecessary complication. Surely the lesson of *Ranger* teaches that. We can ask now, because we asked then, just what did *Ranger* contribute to the U.S. space program? If the answers of a major propaganda triumph and advancement of the technology and techniques of flight to the Moon are sufficient, then the program was worthwhile. But its contribution to *Apollo* was negligible and its contribution to scientific knowledge so sparse that the debate about the lunar surface raged as strongly after the *Ranger* flights as before.

We should also ask now just what is wanted from *Surveyor* and review the program accordingly. Obviously, with an initial flight in May in the offing, it is too late to make any major changes in the spacecraft. But the program should be reviewed so that no more money is spent than is absolutely necessary.

After the basic data for *Apollo* are obtained, any remaining *Surveyor* flights should be scrubbed. Any effort to use *Surveyor* to obtain peripheral data beyond that will be a waste of the taxpayers' money.

It must be remembered that *Surveyor,* already more than three years late on an admittedly over-ambitious schedule, has been termed by a Congressional subcommittee "one of the least orderly and most poorly executed of NASA projects." A great deal has been done to clear up the difficulties which led to those charges. But it is still a fact that *Surveyor* has been so long delayed that its contribution to *Apollo* will be minor, not the major input originally anticipated. Certainly, the success of *Luna 9* has made it less important than ever.

At a time when the demands of the war in Vietnam and of Great Society projects at home are pressing heavily on the budget of the space program, Congress and the National Aeronautics and Space Administration have a duty to see that each space dollar is wisely spent.

There is need to supplement the confirmed data of *Luna 9,* but there is no need for duplication or for quickly obsolescing scientific objectives. Congratulations to the Soviets should be accompanied by critical self-analysis at home.

William J. Coughlin

Phantoms score victories in Viet Nam.

Geminis rendezvous in Space.

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FEBRUARY 21, 1966

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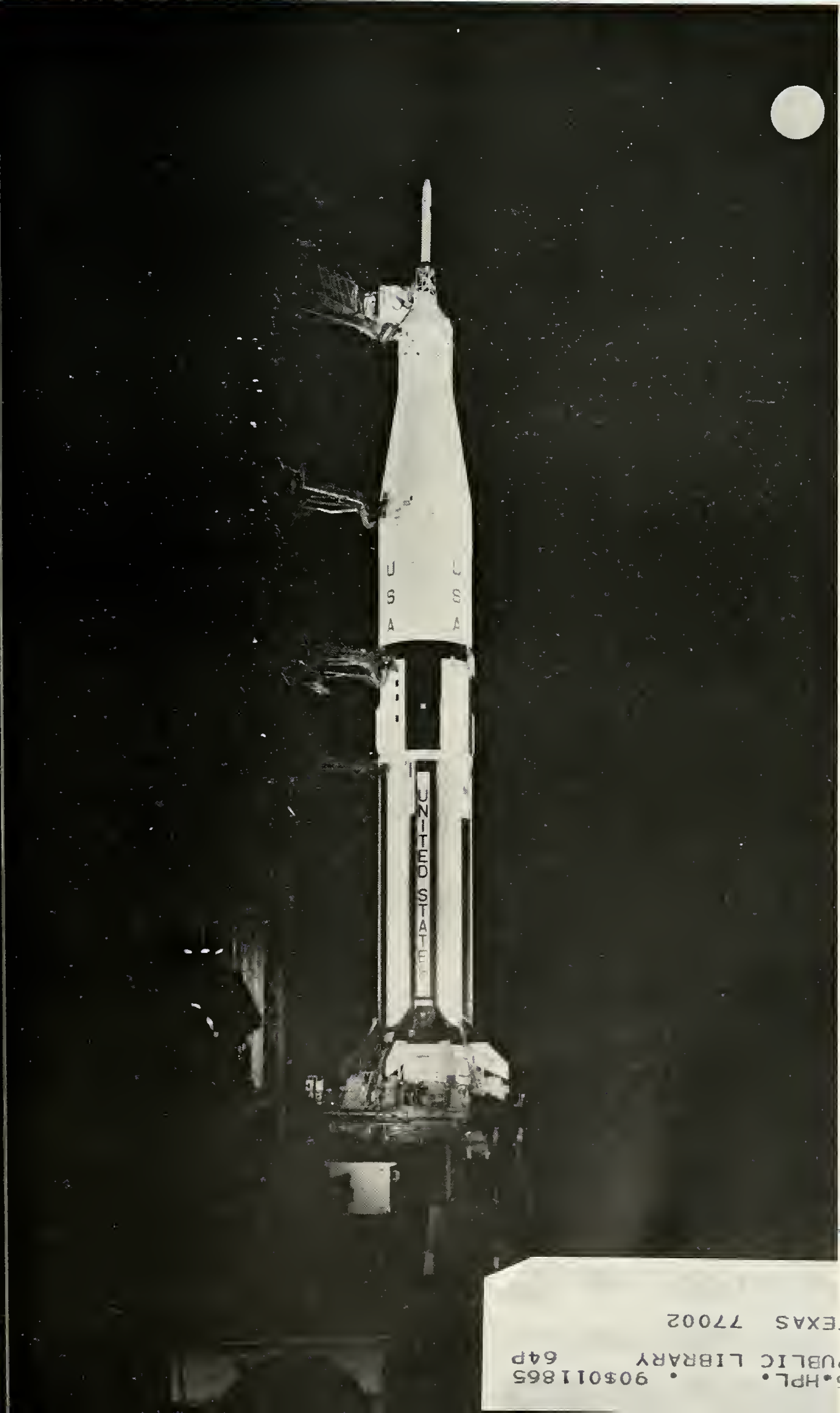

Industry Seen Sharing Mariner '69 Mars Effort

GAO Plans More R&D Investigation

Saturn IB-Apollo Awaits First Test

New Tactical Data System Detailed

Apollo Poised Atop Launch Vehicle at Cape Kennedy

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STRUCTURAL ANALYSIS BS or MS in AE, ME, CE or EM with up to five years experience in structural analysis of aircraft or space boosters.

ECONOMIC ANALYSIS BS in engineering or math with experience in cost analysis or advanced degree in economics with experience in engineering required for challenging assignment in systems analysis. Work will include total program cost analysis, cost-effectiveness evaluation, and cost sensitivity studies of advanced aircraft, missile, space, and marine systems.

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Volume 18, Number 8 February 21, 1966

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THE COVER

Night photo taken at Cape Kennedy shows complete Apollo Command and Service Modules mounted atop Saturn IB launch vehicle. First test of the combination is scheduled this week—5,500-mi. ballistic flight down the Eastern Test Range lasting about 39½ min. See p. 16.

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MEMO FROM THE PUBLISHER

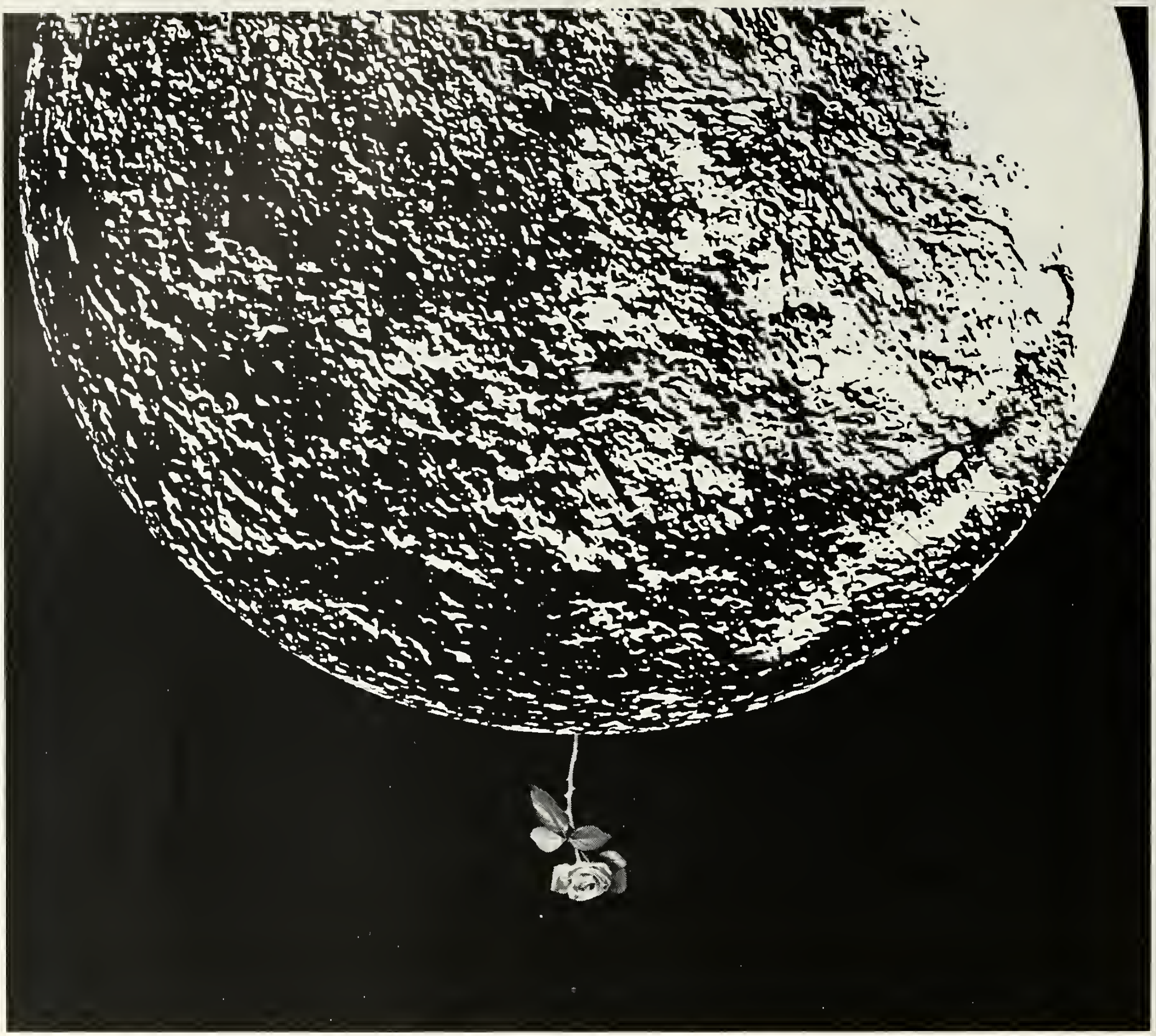
IT IS WITH A GREAT DEAL of pride that I salute the editors of MISSILES AND ROCKETS for recognition by their colleagues in the business press with the Jesse H. Neal Award for 1965. The award, the most cherished in business publishing, was given to the editors of M/R for the best feature article or series of feature articles in magazines with circulations of more than 40,000. The winning entry was the Sept. 6, 1965, special report on oceanology. *Factory* magazine was selected for an equal award in the same class.

The Jesse H. Neal Award, now in its twelfth year, prompted 398 entries this year—53 in the class won by M/R and *Factory*. Although Bill Coughlin, editor of MISSILES AND ROCKETS, was in Vietnam at the time of the presentation, the award ceremony, held on Feb. 16 at the Waldorf-Astoria in New York City, was attended by Reed Bundy, managing editor; William Beller, senior editor; and Fred Schonbach, art director. It was my pleasure to accept the award on behalf of these men and their associate editors.

On the subject of oceanology, I am pleased to report that Robert W. Niblock, assistant public information officer, U.S. Naval Oceanographic Office, Washington, D.C., will join the editorial staff effective March 1 as associate editor for oceanology. Niblock also will direct oceanology coverage for M/R's companion publication, the *Missile/Space Daily*. Mr. Niblock will enhance our ability to report on the many exciting new markets opening in the area of ocean sciences. Many of our readers possess the technology and scientific know-how which will be called upon to explore "inner space." M/R has an obligation to report to you in this and other fields in which missile/space sciences apply to new and rapidly developing areas of advanced technology.

While I'm on the subject of progress, I should mention the growth in advertising pages experienced by MISSILES AND ROCKETS. For the year 1965, M/R showed a healthy gain of 61 pages over the previous year. Although 1966 is still in its infancy, an advertising page gain of 46 pages was recorded for January over the same month in 1965.

James W Claar



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We're helping NASA find the answer as well as probing vital questions of the here and now. Our major programs include LEM inertial guidance system, LEM descent engine, Gemini and Apollo mission analysis, OGO satellites, advanced ballistic missile studies, underwater defense systems, Pioneer interplanetary spacecraft, communications satellites, advanced space probes, Vela nuclear detection satellites, Mars mission studies, telemetry, tracking and control systems, Apollo application studies, advanced propulsion systems, and electronic warfare systems.

These create openings in Inertial Guidance and Control Systems; Mission, Trajectory and Guidance Analysis; Semiconductor Applications; Radar and Sonar Systems; Communications and Telemetry; Experimental Mechanics; Dynamics and Structures Analysis; Aerophysics; Re-entry Systems; Spacecraft Heat Transfer; Space Propulsion Systems; Microelectronics; and Systems Research, Development and Analysis. Why not write us. TRW Professional Placement, One Space Park, Dept. B-23, Redondo Beach, California. TRW is an equal opportunity employer, male and female.

TRW SYSTEMS

The Countdown

WASHINGTON

Non-Profits Report Delayed by Air Force

The Air Force's report on non-profit organizations is said to support the findings of the House Armed Services Special Investigations Subcommittee that made a number of recommendations for tightening the service's control of Aerospace Corporation. Expected imminently late last week, the document reportedly was being held up by the Air Force while it drew up plans for its implementation—the idea being to make both public simultaneously.

NERVA Contract Extension in the Works

NASA expects to begin negotiations about mid-year on an extension of Aerojet-General Corp.'s contract for development of the NERVA engine. Extension will cover the 250,000-lb.-thrust NERVA II engine, which will move into development in FY '67. It will be powered by a Phoebus reactor.

Shillelagh Selection Still Weeks Away

Decision on a firm for second-source production of the *Shillelagh* missile won't come for another five weeks or so. Delay is a result of the highly competitive nature of proposals submitted by General Dynamics/Pomona, Martin, Maxson Electronics, Raytheon and Sperry-Utah. Army Materiel Command is evaluating the proposals. Initial contract, for qualification of a second source, is expected to total nearly $10 million.

First Stirrings of Orbiting Data Relay

NASA expects to award a contract in April for a feasibility study and preliminary design of the Orbiting Data Relay network in which satellites will be used in the relay of tracking data from the ground to satellites as well as from one satellite to another in space. Eight firms are competing for the six-month studies. Development is not expected to be initiated until 1968 or 1969.

Versatility Envisioned for Jupiter Probe

Space agency plans for a Jupiter probe now call for an evolutionary type of spacecraft based on *Pioneer* or *Mariner* which could also be used for exploration of other planets. It would probably weigh 500-600 lbs. and be launched by an *Atlas-Centaur*.

War-Priority R&D Projects Listed

Dept. of Defense's Project PROVOST (Priority Research and Development Objectives for Vietnam Operations Support) has identified more than 150 items for which $58 million from the FY '66 R&D emergency fund already has been earmarked. The $152 million in the supplemental request is going to the continuation and expansion of this effort (see p. 15).

Florida Lawmakers Eyeing MOL Program

A group of Florida senators and congressmen is said to be taking a keen interest in aspects of the *Manned Orbiting Laboratory* program, including launching plans and placement of funds. A meeting held recently in the office of Sen. Spessard Holland was attended by fellow Democrats Sen. George Smathers and Reps. Robert L. F. Sikes and Charles E. Bennett and by Republican Rep. Edward J. Gurney, who represents the district that includes the Kennedy Space Center. Air Force representatives were Dr. Alexander H. Flax, assistant AF secretary for R&D; Brig. Gen. Andrew J. Evans; Dr. Michael Yarymovych; and Col. Richard Dennen.

Cobalt Readied for Unmanned Apollo Shots

Twenty-five millicuries of cobalt-60 distributed among six plugs in aft and crew compartment heat shields of the *Apollo* Command Module being prepared for flight in the *Apollo-Saturn 201* mission Feb. 23 will be used as part of an ablation sensor system for evaluating ablation rates during atmospheric re-entry. Each plug contains seven 5-mil-dia. cobalt wires encased in individual tantalum tubes. The radiation sources will be used on unmanned *Apollo* flights only.

INDUSTRY

Vietnam Effort Producing Shortages

Raw and partially finished stocks for a variety of end-products in the materials, propulsion and communications fields are swiftly becoming mired in a morass of priorities, schedule and delivery delays because of the Vietnam involvement. Communications firms are reporting increasing delays in wire and cable deliveries. Problems are currently confined to military procurements—involving NATO and other far-flung U.S. commitments elsewhere than Vietnam. If the trend continues, commercial products may be affected in certain areas.

Motorola, NCR Offer Apollo Teleprinters

The Military Electronics Div. of Motorola, Inc., and the National Cash Register Co., have been asked by NASA's Manned Spacecraft Center to submit cost proposals on their bids for development of a "hard copy" teleprinter to be carried on board in long-duration *Apollo* missions. Contract will call for demonstrating the feasibility of an 8-lb., 280-cu.-in. unit capable of printing out 1,000 bits per sec.

Litton To Make Post-Apollo Metal Lunar Suit

Litton Industries, Inc., under a $449,800 contract with NASA's Manned Spacecraft Center will develop a fourth-generation all-metal suit for use in post-*Apollo* lunar exploration. Designed with chest and back packs built in as part of the basic garment, the suit is a refinement of an earlier design calling for articulation in wooden shoe-type boots and an improved glove. MSC is leaning toward the "hard suit" for long-time lunar missions requiring repeated excursions. The metal configuration offers long-term wearability, low suit leak rate, and good mobility. Biggest disadvantage is its high storage requirement. Contract calls for delivery of the improved suit by July, 1967.

INTERNATIONAL

Soviet Scientist Stresses Maneuvering

Further indication that the Russians are now turning more attention to gaining maneuvering experience in space appears in a recent article in *Red Star*. Prof. Georgiy Pokrovskiy writes that the USSR is planning rendezvous and docking, assembly of large space stations in orbit, and construction of space stations from which "interplanetary trains" will depart. But he says that to realize all this, "now the maneuvering of spaceships is one of the most urgent tasks of astronautics."

RESEARCH & DEVELOPMENT OPPORTUNITIES IN

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The Tucson Engineering Laboratory of Hughes Aircraft Company is currently expanding its professional staff. Present projects include design and development work in the following fields:

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- Receiver System Design (30 MC to Microwave)
- RFI Analysis
- Reliability
- Missile Structures
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- Missile System Engineering

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OGO-F Experiments Chosen

Twenty-five scientific experiments have been selected by NASA for the sixth *Orbiting Geophysical Observatory (OGO-F)*, scheduled for launch in 1968.

Fifty-five scientists at U.S. and foreign universities, industrial firms and government laboratories will be involved in developing the experiments.

The experimental payload will take up 215 lbs. of the 1,200-lb. *OGO*, which will be launched into a polar orbit with an apogee of 575 mi. and a perigee of 207 mi.

NASA is negotiating with TRW Systems, Inc. for modification of the *OGO* prototype spacecraft to flight status as the sixth in the series of *OGO* launches.

OGO-F investigations will provide detailed information on characteristics of the Earth's outer atmosphere; ultraviolet emissions from the atmosphere and space; characteristics of the auroral zones; the Earth's magnetic field; whistlers and very-low-frequency radio noise; and solar galactic cosmic rays.

LEM Award Goes Incentive

NASA has converted its contract with Grumman Aircraft Engineering Corp. for development of the *Apollo* Lunar Excursion Module (LEM) into a cost-plus-incentive-fee agreement which is expected to cost $1.019 billion.

Together with the $400 million already paid to the firm under the earlier cost-plus-fixed-fee award, the new contract will push the total cost of the LEM development to $1.42 billion.

Under terms of the new four-year contract, Grumman will deliver 15 flight articles, 10 test articles and two mission simulators. This adds four flight articles to the program. The contract, ending Dec. 31, 1969, will complete the LEM requirements for the *Apollo* Moon landing program.

The contract provides profit incentive for outstanding performance, cost control and timely delivery as well as potential profit reductions if performance, cost and schedule requirements are not met.

This conversion marks the second major *Apollo* contract conversion by NASA within the past two months. The agency announced Jan. 21 that it had signed a contract conversion with North American Aviation, Inc., for development of the *Apollo* Command and Service Modules, bringing total cost to $2.2 billion.

Aerojet Motor Firing Set

Test-firing of Aerojet-General Corp.'s second 260-in.-dia. solid rocket motor is scheduled for Feb. 23 at the Dade County, Fla., facility.

The experimental motor, which measures 80 ft. long, is expected to produce 3.6 million pounds of thrust. The first 260-in. motor was successfully test-fired Sept. 25. The two-minute firing produced a peak thrust of 3.6 million pounds and an average thrust of nearly 3 million pounds.

The second firing will complete Aerojet's current contract with NASA.

Gemini Computer Improved

A newly developed tape program storage device which would increase the *Gemini* computer memory capacity by "about 8 times" may fly experimentally on *Gemini 8* and operationally on all subsequent *Gemini* missions.

The auxiliary tape memory (ATM) utilizes the magnetic tape recorder developed by the Raymond Engineering Corp. under contract to International Business Machines Corp., maker of the *Gemini* onboard digital computer. The guidance and control divisions of the Manned Spacecraft Center provided technical direction.

Current *Gemini* computer memory capacity is 12,000 thirteen-bit words. "Although adequate at this time," Bill D. Sturm of MSC explained, "it becomes limited when missions move beyond the current ascent, rendezvous and re-entry program." The core memory is filled to capacity with math flow or the operational program of the type flown on the *Gemini 7/6* rendezvous mission, he said.

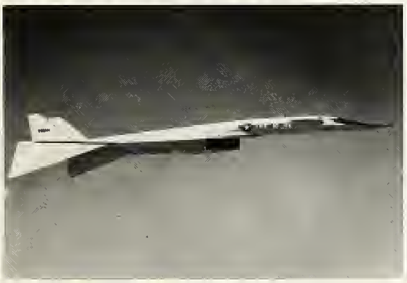
The ATM, a unit 10 x 10 x 7-in., has a storage capacity of 90,000 thirteen-bit words. It contains 525 ft. of 16-channel tape reading at 1.5-ips speed. Besides the mechanical transport assembly, it contains electronics for control logic, motor drive circuitry, error/detect and record/playback logic. Sturm said it takes about six minutes of inflight time to switch from one program to another.

From here to Mars... from –392°to +212°F...

General Electric RTV silicone rubber secures Mariner's 28,224 solar cells

The job was formidable. Jet Propulsion Laboratory engineers needed a temperature-proof bonding agent to mount 28,224 solar cells in place on the four Mariner panels for its flight to Mars. JPL chose General Electric's flexible RTV-40 silicone rubber adhesive because it met design requirements: long-term resistance to environmental stresses from —392°F to 212°F. Did RTV-40 do its job? After many months in space and 21 spectacular close-ups of the Martian surface, we're inclined to say it did.

PROTECTION FROM DIRECT FLAME in fire areas is practical with silicone rubber. The jet engine oil tank shown here was coated with General Electric RTV-577 silicone rubber, exposed to a 2000°F flame for 16 minutes with no oil leakage or spillage during or after the flame exposure. Coated areas were still completely covered.



NEW TEMPERATURE-RESISTANT COATING on wings and fuselage of North American's XB-70 No. 2 contains General Electric silicone resins. The new silicone coating stays flexible at low temperatures, clings tenaciously to the substrate when the structure flexes in flight. It withstands heat too — up to 600°F at Mach 3.

WINDOW SEALS ON NASA'S APOLLO must withstand weight loss in vacuum, be non-toxic, perform uniformly in alternating hot and cold. After testing 14 high performance elastomers, North American Space Division used G-E RTV-560 silicone rubber as the sealant. RTV-560 retains high flexibility down to —160°F, meets non-flexible compression requirements down to —200°F.

For a free sample and more information about General Electric RTV silicone rubbers, greases, fluids, etc., write to us on your letterhead, describing your application. Write Section 02190, Silicone Products Department, General Electric Company, Waterford, New York 12188.

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The study to enlarge the computer's memory capacity without alteration to the computer was undertaken two years ago by MSC. IBM was awarded a $2-million contract in June, 1964, to develop a digital magnetic tape recorder and necessary software. The first of five flight units was installed in *Gemini 8* last month.

By adopting the tape recorder as a memory device, "we had to overcome the high error rate inherent in magnetic tape," he said. This was done by having the ATM record each data bit three times. During playback, a special circuit would then vote on the best two out of three bits in the event one bit dropped out or became distorted by a dust particle or a blemish in the tape. A parody bit is also stored redundantly on the tape and compared for accuracy. The redundancy feature reduces the expected tape error rate from approximately one every 7,700 words to approximately one every 84 million words.

Shots of the Week

A *Scout* booster was fired from Wallops Island Feb. 9 to test a new heat shield material under extreme temperature conditions. The material tested was made of phenolic nylon plastic.

- The Air Force launched a secret satellite from Vandenberg AFB, Calif., Feb. 15 aboard an *Atlas-Agena* rocket.
- A *Titan II* booster was successfully fired from Cape Kennedy Feb. 10. It was the spacecraft's 13th consecutive success.
- The Army successfully fired a *Pershing* missile Feb. 14 from Hueco Range, north of Fort Bliss, Tex. The missile impacted on White Sands Missile Range, N.M., 120 mi. away.

Schirra, Borman on Tour

Astronauts Walter Schirra and Frank Borman will leave this week on an eight-country goodwill tour.

The two astronauts will visit Japan, Korea, Taiwan, Malaysia, Thailand, the Philippines, Australia and New Zealand. The three-week tour is to demonstrate the scientific, technological and education value of the U.S. space program.

TOW Tested in Arctic

Arctic testing of the *TOW* anti-tank missile system is under way at Fort Greeley, Alaska, by the Army Missile Command and Hughes Aircraft Co.

Test firing of the wire-guided missile will be conducted in temperatures down to —25°F to determine the system's operation under extreme weather conditions. Assembly, disassembly and carrying by troops in the field will also be tested.

Navy R&D Director Named

Dr. Gerald W. Johnson has been appointed director of the Navy's R&D laboratories.

Johnson, formerly of the Lawrence Radiation Laboratories, will also act as principal advisor to the assistant secretary of Navy for R&D. Facilities under his administration include the Naval Research Labs, the Naval Ordnance Labs and the David Taylor Model Basin.

Power System Studies Begun

Three firms will conduct parallel feasibility studies of a 250- to 300-watt isotope-fueled thermoelectric power source for the Atomic Energy Commission.

General Electric Co., Martin Co. and Lockheed Missiles and Space Co. were selected for the six-month studies, aimed at determining "long-lived Earth-orbit applications." Total cost of the three contracts is approximately $460,000. The studies will cover investigation of advanced technology aimed at lightweight design and safety requirements, including controlled re-entry.

Funk Cites AF Needs

Four principal aims in advanced technology have been outlined for U. S. industry by Maj. Gen. Ben I. Funk, commander of the Air Force Systems Command's Space Systems Div.

Gen. Funk said the Air Force is seeking practical solutions to the problems of developing reusable boosters, maneuvering re-entry devices, lighter-weight materials and higher-performance fuels.

He offered this challenge to those attending the recent Mid-Winter Conference of the National Assn. of Manufacturers in New York City. His talk outlined the importance of space developments to U. S. industry, and the need to keep the nation first in technological ability.

Funk said that industrial superiority "is a vital and irreplaceable national resource," and that the responsibility for maintaining this superiority rests "not only upon the defense producers but on all of American enterprise."

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Industry To Share in Mariner Task

Firm may be selected for systems support by third quarter of this year; NAS group advocates exploration of Jupiter

by Hal Taylor

IT IS NOW almost certain that NASA will select an industrial firm as a systems support contractor for development of the *Mariner* Mars 1969 spacecraft—perhaps as early as the third quarter of this year.

In another lunar and planetary program development, increased activity centering around a Jupiter probe apparently means it is moving closer to development and may eventually serve as part of a new international space cooperation program.

A National Academy of Sciences group recently reported its recommendations on future lunar and planetary programs, with primary emphasis on a Jupiter probe, to NASA Administrator James E. Webb and Deputy Administrator Robert C. Seamans, Jr., on Feb. 12 and 13. The report, according to one leading scientist on the panel, was received "sympathetically."

In discussing the possibility of a systems contractor for the two 1969 exploration missions to Mars, a NASA official indicated that it is almost certain that there will be one, but just how much work will be done by the contractor is still far from decided.

Contractor role undetermined—It involves the question of whether the contractor will serve in a supporting role in terms of applying engineering know-how to the program or whether the contractor will also be called upon to do some of the hardware development work.

The scope of the work will not be resolved until a determination is made as to what facilities and personnel will be available for the project at Jet Propulsion Laboratory, which has field center responsibility for the *Mariner* program.

The NASA official indicated that the earliest a decision will be made would be early in Fiscal 1967.

If the decision is made early in the fiscal year, the contractor could be onboard by mid-summer. If it is delayed, the contractor selection might have to be put off until near the end of the year.

Money limits weight—The 1969 *Mariner* Mars will be an 800-lb. spacecraft launched by an *Atlas-Centaur* on a fly-by trajectory to Mars. The weight is well below the full capability of *Centaur,* but is dictated by funding limitations. The spacecraft is expected to make heavy use of *Mariner* technology. It will probably carry 70 lbs. of experiments, 30 lbs. being on the scan platform. In comparison, *Mariner 4* carried 40 lbs. of instruments with 8 lbs. on the scan platform.

Mariner '69 is expected to have a data storage capability of 10 million data bits, compared with the 5 million bits of *Mariner 4*.

Mariner '69 preliminary design is expected to continue through the first half of 1966. Detailed design, hardware development, and qualifications testing of the spacecraft will take place during the second half of 1966 through the first half of 1968. Flight spacecraft testing will then take place until the launch, early in 1969.

In discussing the Jupiter probe, one scientist estimated that it would cost about $30 million per year using either a modified *Pioneer* spacecraft or a new spacecraft powered by electrical propulsion. He estimates that the earliest it could fly would be 1970.

A NASA official indicated that while feasibility studies of such a probe have been completed, preliminary design and systems definition probably will not be funded until Fiscal 1968.

President Johnson's recent bid to West Germany's Chancellor Ludwig Erhard to join the U.S. in a Jupiter probe program, as well as the support obtained from the National Academy of Sciences, could speed up its development. ■

Agena Blast Clouds Gemini Schedule

SPACE AGENCY officials continue to push for a March 15 launch date for the *Gemini 8* mission with the *Agena* rendezvous target vehicle despite an explosion that wrecked a test engine at the Arnold Engineering Development Center.

The officials declared that while no final decision had been made late last week, they did not think the explosion would delay the mission or force substitution of the Alternate Target Docking Adapter (ATDA) developed by McDonnell Aircraft Corp. as the rendezvous target.

The explosion—which occurred during an engine ignition test at a simulated 80,000 ft. in the AEDC wind tunnel—apparently was caused when water was allowed to contaminate the engine, according to NASA officials. The officials said that while their investigation had not been completed, the engine failure did not appear to be similar to the hard-start explosion that forced the *Gemini 6* mission to be aborted last Oct. 25.

The AEDC test series on the *Agena* engine began Feb. 7. Five high-altitude ignitions (400,000 ft.) were successful.

While engineers studied data from the successful firings, it was decided to clean up the facility before testing was resumed.

A quantity of water was discovered in the *Agena* engine after the clean-up operation and efforts were made to purge it.

Since some minor changes had been made to the engine and the facility during the testing lull, officials decided to proof-test the engine at the low altitude of 80,000 ft. to insure that the changes had been made correctly.

It was at this point that the explosion occurred and the engine suffered extensive damage.

Officials now believe that not all the water was purged out of the engine and the residue caused it to explode. The investigation continued late last week, however, and neither NASA nor the Air Force, which developed the *Agena,* had officially certified what caused the malfunction.

Since there was only minimal damage to the wind tunnel facility, NASA on Feb. 17 rushed an *Agena* engine—which had been undergoing sea-level firing tests at the Bell Aerosystems plant in Buffalo, N.Y.—to AEDC. Plans called for them to resume testing with the new engine in the wind tunnel Feb. 21.

GAO May Press Probe of Federal R&D

Agency discloses critical results of survey of management practices at AFCRL; Staats named comptroller general

by Heather M. David

THE GENERAL ACCOUNTING OFFICE has indicated it plans to delve further into Federal agency research and development operations and has already done an in-depth study of the Air Force Cambridge Research Laboratories as a means of acquainting itself in the field.

In another GAO development, President Johnson has appointed former deputy director of the Bureau of the Budget Elmer B. Staats to the position of comptroller general, a post that has been vacant some months because of the illness of former Comptroller Joseph Campbell, who resigned.

Staats has had many dealings with matters concerning the missile/space industry and research and development activities. In 1962, he was involved in testimony before the House Government Operations Committee's military operations subcommittee in hearings on missile systems.

Last year, he went on record with some of his views on the nature of the General Accounting Office itself in testimony before the same committee in its probe of disagreements between the Defense Department, DOD contractors and the GAO.

In that testimony, Staats indicated regarding GAO's right to venture into management judgments that he felt that the criticism of GAO was sometimes justified, but that in the nature of GAO's auditing function it would naturally fall somewhat into this area.

At that time, however, he voiced his opinion that the line would have to be drawn "with discretion" by GAO. Speaking from his position with the Bureau of the Budget, he said ". . . we would welcome their observations, suggestions, and recommendations, but we would stress at the same time that they are of an advisory character."

The entry of GAO into the management judgment area was one of the issues strongly protested by defense contractors in the hearings.

Cambridge Research Labs—The recent GAO survey of AFCRL was carried out with the intention of "obtaining information on the management procedures followed with respect to a Government research laboratory for use in determining the direction and nature of future examinations into the management of Federal agency research operations," the GAO said.

While AFCRL is an in-house laboratory of the Government, GAO said, it nevertheless contracts out about 80% of its research and development funds. Although not making a judgment on the advisability of this procedure, it noted that laboratory scientists who make the decisions whether or not to contract out work "should be required to document the reasons in support of their decisions to have work done under contract rather than in-house."

It also noted that the same laboratory scientist who makes the decision to have the work done under contract very often is designated contract monitor, and thus could participate in all the significant technical aspects of a procurement—from conceiving of the idea for the work to deciding whether to award the contract on a sole-source basis, and whether to extend it year after year. The procurement office does not have technically qualified personnel on its staff, the GAO said, thus depending upon the monitor for all technical aspects of the procurement.

Want more records kept—GAO faulted many aspects of the Research Laboratories' record-keeping practices, including the fact that no records are maintained on individual contractor employees, their working hours and the like. The military auditors have no way to verify after the fact that time actually was spent on contracted work, GAO said.

Auditors also said the involvement of so many agencies in financing research and development work would appear to be a "complicating factor" in the financial management of AFCRL's operations and tends to limit the effectiveness of the management control exercised by its parent organization, the Office of Aerospace Research, over those operations. The Air Force, however, denied that any complications existed.

GAO also disclosed that it is looking at the problem of the use of contractor personnel to do work "which civil service employees are capable of doing," a subject which also has been studied by the House Committee on Post Office and Civil Service subcommittee on manpower.

Some lack of control over use of independent research and development program funds also was hinted at. The GAO indicated that the current procedure for review does not seem to provide assurance that the work was done in accordance with the agreed-upon program.

GAO also concluded that the AFCRL accounting system does not meet the requirement that each executive agency provide full disclosure of the financial results of the agency's activities and produce financial information adequate for agency management purposes. ■

Vietnam Debate Delays Vote on Supplemental

PASSAGE of the DOD supplemental authorization bill is being held up in the Senate because it has become a platform for debate on the country's position in Vietnam. Thus, a vote on the $4.8-billion measure is not expected to be called until sometime this week.

The Senate Armed Services Committee last week reported out the bill, allowing the full amounts requested by the Administration for procurement and research, development, test and evaluation. Its House counterpart is still considering the bill.

Total procurement provided in the bill amounts to $3.417 billion, since the remainder of the $7 billion procurement request in the supplemental bill does not require authorization.

Included in the Senate committee's recommendations is $64 million for Army missiles, which is earmarked for ground support equipment for *Hawk*. Navy missiles—mostly *Bullpup*—are recommended at $26.2 million, and Marine Corps missiles at $27.5 million.

The Air Force missile procurement recommendation of $63.7 million is to be used for *Bullpup* air-to-ground missiles to equip the F-105 and F-4 aircraft, as well as target drones to evaluate AIM-7E *Sparrow* air-to-air training requirements and to accomplish pilot combat training.

Saturn IB-Apollo Awaits First Test

Ballistic flight will evaluate compatibility of launch vehicle and spacecraft, verify heat shield design during re-entry

U.S. SPACE OFFICIALS shortly will attempt to achieve two major milestones—the first launch of the *Saturn IB-Apollo* combination and the first full-thrust hot firing of a nuclear rocket engine.

Both of the space age spectaculars could take place as early as Feb. 23, but the NERVA test may be delayed until March 2, primarily to give officials more time to study data from previous firings.

The unmanned ballistic flight of the *Apollo* spacecraft will be made from Cape Kennedy. Impact and recovery are slated to take place 5,500 mi. downrange in the South Atlantic.

The hot firing of the NERVA reactor will take place at the Nuclear Rocket Development station at Jackass Flats, Nev. It is the culmination of a three-week series of tests designed to prove the feasibility of the breadboard NERVA engine in actual operation. (See box, p. 17).

The *Apollo-Saturn* vehicle, with a height of 224 ft., is the largest ever erected at Cape Kennedy and its spacecraft payload, with a weight of 45,900 lbs. is the heaviest ever to be launched by the space agency.

This week's flight will be the first of three unmanned *Apollo* flights scheduled for this year. If all are successful, it is possible that the first manned flight with its crew of three astronauts could be made late this year. That would depend on a turn-around time of about 2½ months between launches. NASA is not optimistic that such a schedule could be maintained and officially reports that the first manned flight will not be made until 1967.

The *Saturn IB* is the most powerful launch vehicle ever developed by NASA. It has a total thrust of 1.6 million lbs. in the first stage and a 200,000-lb.-thrust second stage.

It will blast the spacecraft to an altitude of 300 mi., from which point the Service Module propulsion system will be used to ram it back into the atmosphere. Total flight time will be 39½ min.

Mission goals—The prime objectives of the mission are:

—To demonstrate structural integrity and compatibility of the launch vehicle and spacecraft and to confirm launch loads.

—To demonstrate separation of the launch vehicle stages, instrument unit, and segments of the spacecraft in the correct sequence.

—To verify operation of the launch vehicle propulsion, guidance and control, and electrical systems.

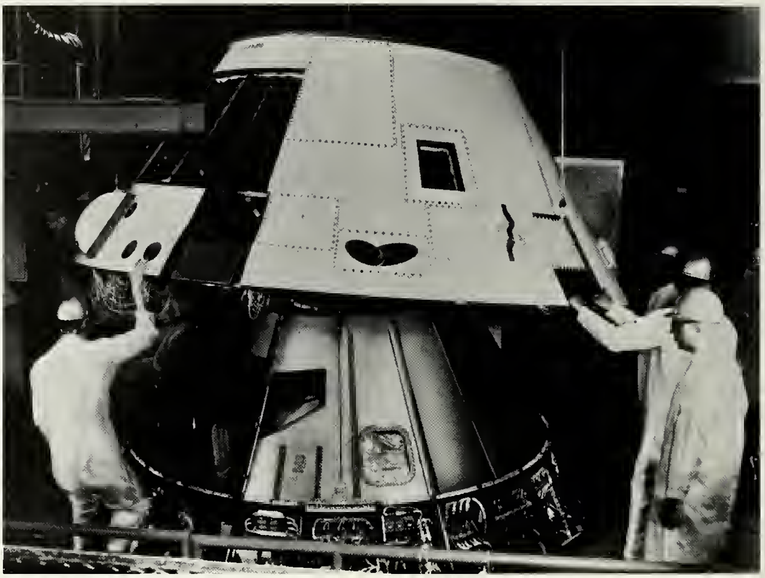
—To verify operation of the Command Module heat shield for re-entry into the atmosphere from low Earth orbit at a velocity of 18,000 mph at temperatures up to 4,000°F.

—To verify operation of the Service Module propulsion system including restart of the main engine.

—To prove the operational capability of spacecraft systems such as environmental control, reaction control, launch escape, and the recovery system. There will also be limited tests of the communication and electrical power systems.

—To evaluate the emergency detection system in preparation for its use on manned flights.

The *Apollo-Saturn IB* will be launched from Complex 34 on an azimuth of 100 degrees east of north, an east-southeast direction from Cape Kennedy. It will be held on the pad for about three seconds after the eight first-stage engines ignite, to assure stable combustion.


Crew compartment heat shield for Apollo 009 is lowered over inner crew compartment. Upcoming launch will help verify heat shield at 18,000-mph re-entry speed.

Flight plan—After liftoff the vehicle will roll into an azimuth of 105 degrees and begin to tilt in the direction of the flight path.

The first-stage engines will burn for 2 min., 26 sec. before the stage is separated. The second stage will then ignite, the launch escape tower will be jettisoned, and the recoverable cameras that photographed the separation sequence will be ejected.

The second-stage engine burns for about 7 min., 20 sec. After burnout the stage and the instrument unit remain attached to the spacecraft for about 4 min. Attitude-control rockets on the second stage orient the spacecraft so that the apex of the Command Module is pointing toward Earth.

About 13 min. and 53 sec. after launch, the second stage and instrument unit separate from the spacecraft.

The Command and Service Modules coast to a peak altitude of 310 mi. above the Earth about 2,750 mi. downrange from the launch pad.

Approximately 2 min. later, in the early phase of the descending flight, the reaction-control system rockets in the Service Module fire for 30 sec., which will increase the speed of the spacecraft a few miles per hour. This is an ullage

MAJOR APOLLO-SATURN IB CONTRACTORS

SATURN IB

First stage	Chrysler Corp. Space Div.
H-I engines	North American Aviation, Inc. Rocketdyne Div.
Second stage	Douglas Aircraft Co., Inc. Missile & Space Systems Div.
J-2 engine	North American Aviation, Inc. Rocketdyne Div.
Instrument unit	International Business Machines Corp. Federal Systems Div.
ST-124M inertial platform in the instrument unit	Bendix Corp. Eclipse Pioneer Div.

APOLLO SPACECRAFT

Command Module, Service Module and LEM Adapter	North American Aviation, Inc. Space & Information Systems Div.

SUBCONTRACTORS FOR MAJOR SPACECRAFT SYSTEMS

Ablative heat shield material	Avco Corp. Research & Advanced Development Div.
Brazed honeycomb panels	Aeronca Manufacturing Co.
Command Module attitude control and stabilization engines	North American Aviation, Inc. Rocketdyne Div.
Communications & data system	Collins Radio Co.
Control programmer	North American Aviation, Inc. Autonetics Div.
Earth landing (parachute) system	Northrop Corp. Ventura Div.
Environmental control system	Garrett Corp. AiResearch Div.
Launch escape and pitch control motors	Lockheed Propulsion Co.
Service Module propulsion engine	Aerojet-General Corp. Propulsion Div.
Service Module reaction control system	Marquardt Corp.
Stabilization and control system	Honeywell, Inc.
Telemetry data processing system	Radiation, Inc.
Tower jettison motor	Thiokol Chemical Corp.

GROUND SUPPORT EQUIPMENT

Apollo spacecraft acceptance checkout equipment (ACE)	General Electric Co. Apollo Support Dept.
Saturn 110A checkout computer and display systems	Radio Corp. of America Aerospace System Div.

maneuver, which forces liquid propellants to the bottom of the storage tanks, thus insuring ignition of the Service Module main propulsion engine.

The main propulsion engine then burns for 3 min., adding about 3,100 mph to the spacecraft's velocity. After a 5-sec. coast another ullage maneuver is performed and the Service Module propulsion engine re-ignites and burns for 10 sec.

This increases the velocity to more than 18,000 mph, which is greater than re-entry speed during *Apollo* orbital missions.

The spacecraft will then pitch over so that the blunt end of the Command Module faces Earth. Reaction control engines are fired to separate the Service Module from the Command Module.

The Command Module will then pitch and roll to the re-entry attitude and re-enter the atmosphere at an altitude of 400,000 ft. This occurs 25½ min. into the flight. A communications blackout begins 30 sec. later.

Drogue parachutes are deployed to stabilize the spacecraft after 34½ min. of flight. Less than a minute later the main chutes deploy at 12,000 ft.

Splashdown is programmed 39 min., 28 sec. after liftoff. ■

Full-Thrust NERVA Firing May Slip a Week

THE UPCOMING hot firing of the NERVA rocket engine is designed to achieve a full-power run of 1,100 megawatts or a thrust of 55,000 lbs.

No decision has yet been made as to the duration of the firing, but it will apparently depend upon how well the engine runs after ignition.

The firing is scheduled for Feb. 23, but there are indications it could be delayed by about a week to give officials further time to study the data from previous firings before committing the engine to a full-thrust test.

The upcoming test culminates a series of firings that began on Feb. 3.

The principal objective of that test was to demonstrate the capability of a nuclear rocket engine to start itself using only the energy contained in the system. The bootstrap start-up used pressure in the hydrogen propellant tank and the heat of the reactor to start the engine without external energy sources.

The start-up was first initiated under normal temperature conditions (approximately 60°F) and then under conditions in which the reactor was pre-chilled to a temperature of approximately 350°F below zero.

The engine was operated for 25 min. at intermediate power during the initial start and one re-start.

The engine was restarted twice Feb. 11 and operated at intermediate power of 250 megawatts for approximately 30 min. It reached a thrust level of 12,500 lbs.

The principal objectives of the tests was to further demonstrate the system's bootstrap capability under different conditions.

The start-up was first initiated with the reactor control drums in a pre-set position to explore the possibility of using a simplified reactor control system. The second start was conducted under conditions of reduced pressure in the hydrogen propellant system.

The power tests at the Nuclear Rocket Development Station, Jackass Flats, Nev., are a part of this country's Project Rover—designed to develop a nuclear-powered upper stage for use in U.S. launch vehicles.

It is a joint AEC/NASA program.

The contractor team for NERVA is Aerojet-General Corp. on the NERVA engine and Westinghouse Astronuclear Laboratory for the reactor.

If the full-thrust firing is successful, it will mark a major step forward in the Rover program. Although the NERVA engine is not designed to fly in space, a successful test will insure a go-ahead for the NERVA II engine, which will have a thrust of 250,000 lbs.

Biomedical Space Technology Lagging

Science board calls for manned orbiting labs for human factors research; more ground-based study also urged

THE THIRD OF A SERIES of reports by working groups of the National Academy of Sciences/National Research Council's Space Science Board charges that biomedical data and systems have not kept pace with space-vehicle technology and are in some cases deficient because of their emphasis on engineering aspects of current space programs.

The medicine and physiology group, chaired by Dr. L. D. Carlson of the University of Kentucky Medical Center, urges the undertaking of a series of spaceflights specifically designed to study the biomedical problems of prolonged space flight.

The Space Science Board said that a necessity in this field is the flight of a series of manned orbiting research laboratories to conduct medical, physiological and behavioral research required for prolonged space flight up to 1,000 days.

The board also called for an expansion of the nation's sounding rocket program by a factor of between two and three over the coming five-year period, a recommendation which echoed those made by scientists in individual discipline groups.

This rocket program expansion should be undertaken even at the cost of a stretch-out of the satellite program, the board said. However, it also stressed the need for the currently planned schedule of near-space satellite research.

Improvements in shipboard launchings, increased thrust and development of better attitude-control systems and air recovery methods were also suggested. More cooperative effort with universities and other countries was stressed.

Manned flights—"Present spacecraft allocated to the manned program probably are not capable of performing all the necessary research," the board said in its report. It recommended that the laboratories be designed for at least six to eight men and have ample working space for experimentation.

An "urgent" requirement also is the improvement of life-support systems for long-term flights. Those currently in use or in advanced stage of development are deficient, the group said, in cabin atmosphere, waste management, humidity control, food handling—and in some respects, in biomedical data collection for prolonged flights.

"Current methods of sensing, recording, and telemetry are primitive in comparison with the sophistication of many other spacecraft components," the group said. Among the things which should be added to the list of requirements, it indicated, is monitoring equipment for quantitative estimation of the astronaut's physiological reserve and prediction of his responses to activity and to emergency.

It added that other valuable data which has not been received to date could be derived from continuous inflight monitoring of physiological systems.

Ground studies—The scientists called for broadening and acceleration of ground-based biomedical research, including not only the study of combined and single spaceflight stresses but attempts to clarify the fundamental nature and morphology of the physiological and behavioral processes likely to be affected by space flight.

The group also chided the biomedical specialists for failing to efficiently communicate research results. "Some organizations evidently prefer to issue results of their biomedical research through their in-house publications rather than through national or international journals."

Beefing up of NASA's life sciences staff was also recommended in the form of a study to determine the best way to attract specialists to bioastronautics and training and retaining them.

Biology—Extension of the *Biosatellite* program beyond the currently planned series was urged, together with use of a launch vehicle capable of boosting a scientific payload of several hundred pounds into orbit in a manner that avoids some of the constraints of the current program.

Another apparent problem identified by the group was the lack of effective communication between experimenters and spacecraft design engineers. Increasing the personnel complement at Ames Research Center, the report suggested, would provide more engineering advice and aid in developing experiments.

Some of the biological problems warranting attention were listed as weightlessness, radiation, biorhythms and vibration.

In the exobiological field, the scientists pointed out that attention should be given to the possibility that no life exists on Mars, but that prebiotic organic chemistry could be characterized in a study of all stages of the evolutionary development of life on a planet.

The board once again stressed the importance of the development by NASA of the *Automated Biological Laboratory* (*ABL*) in the biological exploration of Mars.

However, the group said that complete biological and other investigations ultimately will require travel by scientists themselves to Mars. To this aim, bioregenerative life-support systems research should be supported.

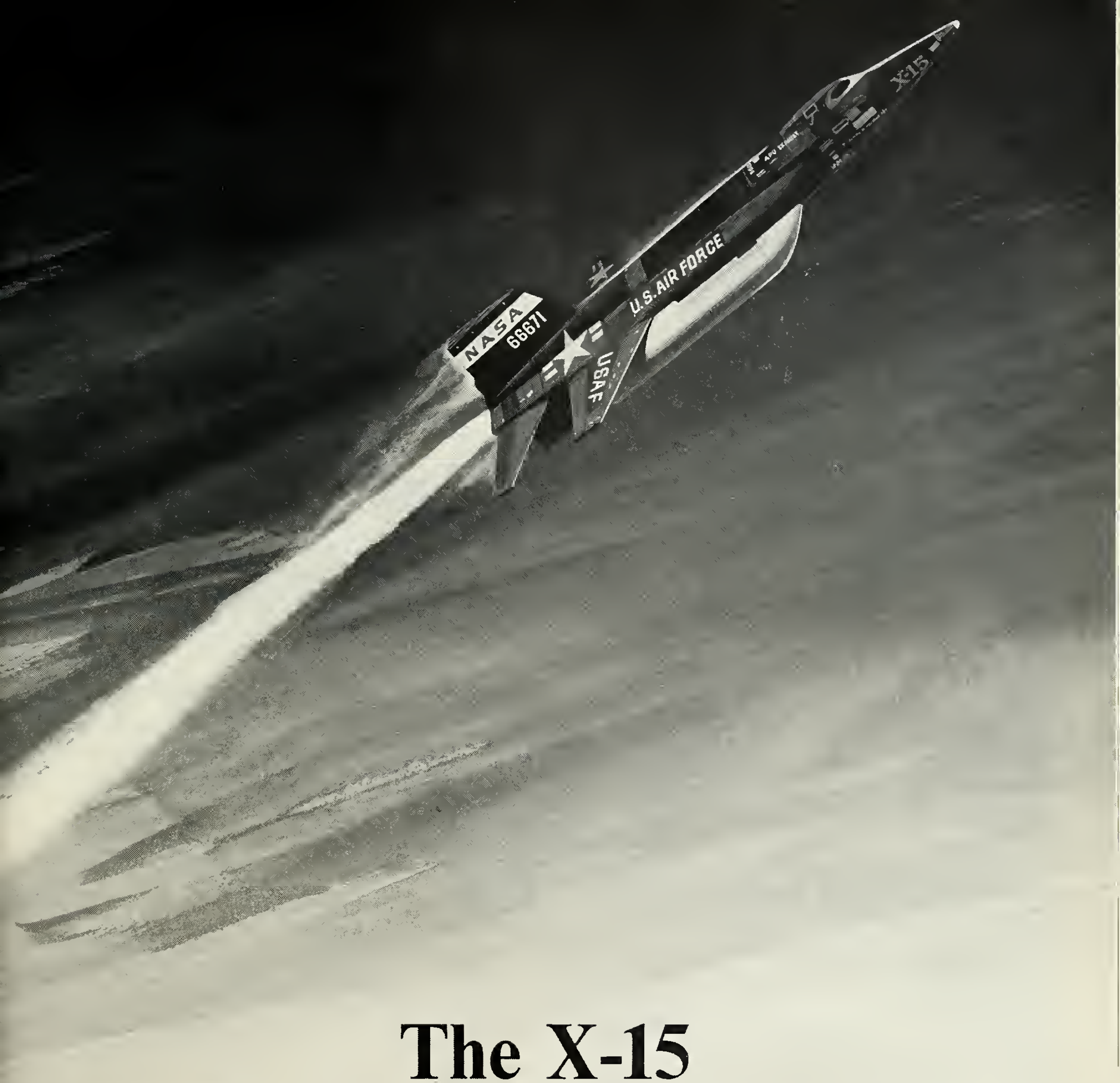
Scientist-astronauts—The plea for more scientists in the space program was reiterated throughout the report. The board called for a new category of astronauts—scientist-passengers who could devote their entire time and concentration to scientific investigations.

With future spacecraft technology, the report suggested, the stringent physical standards which are required for pilot-astronauts could be lowered. Otherwise, they could result in an excessive limitation at the expense of needed scientific qualifications.

Gemini-Apollo—In a final summary session of all the working groups, the scientists endorsed the experiment program of *Apollo* and *Gemini*. However, it emphasized that in order to attract competent research scientists to the kinds of space experimentation that involve man, it would be desirable to assure that the experiments will be completed.

"Such considerations may suggest that some adjustments in procedures and attitude toward the experimenter may be necessary to encourage the scientific community to use this new capability in space research."

The first report in the board's three-part series concentrated on lunar and planetary exploration and called for increased emphasis on unmanned exploration of the planets (M/R, Jan. 24, p. 15). The second report covered optical astronomy, solar astronomy, radio and radar astronomy, X-ray and gamma-ray astronomy and physics and geophysics. The board urged an increase in solar observatory work (M/R, Feb. 7, p. 15). ■



The X-15

This is the amazing hypersonic X-15 research vehicle—part missile, part airplane, part spacecraft.

n the atmosphere it flies like an airplane. At the edge of space, it s controlled by small reaction jets, like the Gemini spacecraft.

The X-15 has rocketed to a world record speed for winged ircraft: 4,104 mph. And attained a record altitude of more han 67 miles—above 99.999% of the earth's atmosphere. It s a vital link between manned controllable flight in the atmoshere and manned space flight. Three Air Force pilots have arned their astronaut wings in it.

The most successful experimental aircraft in aviation hisory, three X-15's have completed more than 156 test flights n six years of service. They have made vital contributions to irframe structure, aerodynamic heating, heat transfer, stability-nd-control, ballistic controls, propulsion, and bioastronautics.

Now the X-15 is being used as a flying research laboratory. Future X-15 experiments, not possible with any other vehicle of today, could explore the characteristics of hypersonic flight and test advanced engine concepts.

The X-15 was built for NASA and the U.S. Air Force by North American Aviation. Together with the North American-built Mach 3 XB-70, it is a vital contributor to America's future leadership in high-speed, high-altitude military and commercial flight.

North American Aviation contributes to the nation's growth and security in many ways. It is building the Apollo spacecraft to carry man to the moon; producing the first fully-integrated microelectronics system to provide the Minuteman ICBM with improved reliability and accuracy; and building the F-1 rocket engine, the largest liquid rocket engine in the Free World.

North American Aviation

Atomics International, Autonetics, Columbus, Los Angeles, Rocketdyne, Science Center, Space & Information Systems

For the go generation—Sperry strapped-down inertial.

Our experience in strapped-down inertial systems began in 1960, and is supported by both company-funded and contracted work. In fact, we flew a strapped-down inertial measuring unit in 1961. The required genus of computer for high capacity, real time conversion is flight proven. ☐ Currently Sperry is producing 3-axis Inertial Reference Units for long duration space missions. ☐ We're convinced that strapped-down inertial will provide the reliability, low power/weight and system redundancy required for future launch vehicles and interplanetary spacecraft. Sperry has the long-term technical investment and space-proven components to back that conviction.

INERTIAL DIVISION, Sperry Gyroscope Co., Great Neck, N.Y.

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Technical Countdown

ELECTRONICS

High-Energy Laser Pump Developed

A rugged coaxial pump, designed by Westinghouse Research Lab scientists, will power laser rods some three feet long. The coaxial pump repeatedly handles 70,000 joules of energy. During operation, peak power input is about 100 million watts. The pump acts as its own reflector—eliminating bulky and expensive cavities associated with conventional flash tubes. The Westinghouse unit consists of two quartz tubes of different diameters, one inside the other. A metal electrode holds the tubes together and the laser rod fits inside the inner quartz tube. The electrical discharge occurs between the two tubes, forming a hollow cylinder of light completely surrounding the laser rod. The other tube is coated to act as a reflector. During firing, the inner quartz tube is under compressive forces. A high-quality laser rod supplied by American Optical Co. and pumped with the Westinghouse tube showed a slope efficiency in converting electrical input to coherent light output of 5.1%.

High-Temperature Antenna Handbook Out

Antenna design technology, aerospace vehicle thermal environments and the properties and limitations of high-temperature materials are now available in a concise 150-page handbook compiled by Cornell Aeronautical Laboratory. The compilation includes ways and means of taking advantage of the vehicle environment to so position antennas as to keep the operating environment below 2,000°F. The review includes ablation materials, high-temperature seals, performance of experimental antennas and the design of the thermal environment. The handbook was prepared under the sponsorship of the Air Force Avionics Laboratory, R&T Div., Air Force Systems Command. Qualified requestors should obtain copies from the Defense Documentation Center (DDC), Cameron Station, Alexandria, Va. 22314.

Lasers a $97-million Industry

Lasers accounted for over $97 million worth of business during 1965, with some 41% of this in direct manufacturing activity. Patrick J. McGovern, president of International Data Corp., says that at least 367 organizations are doing laser or laser-related work. Of these, 257 are industrial firms, 75 are nonprofit concerns such as universities and foundations and 35 are military and civilian agencies of the government. The industrial breakdown includes 151 firms engaged primarily in manufacturing, 95 primarily R&D, nine exclusively applications-oriented and two making a business providing consultation services. Total amount spent by manufacturers hit $51.9 million (53.4%), R&D accounted for $21.1 million (21.7%), and consultants had $150,000 worth of fees. Government agencies spent $10.3 million (10.6%) and the nonprofit group poured $12.4 million into the laser economy.

LIFE SUPPORT

Long-Term O_2 Partial-Pressure Sensors Studied

NASA is considering several approaches in the development of an oxygen partial-pressure sensor for extended-duration missions, including using the paramagnetic properties of oxygen. One method is based upon the variation of metal oxide film conductivity with oxygen partial pressure. Two research programs will lead to demonstration models in the near future, NASA said. One effort covers the application of solid electrolyte technology, the other a thin-film technique. NASA-Langley is handling the work.

SPACE MEDICINE

Vibration Offset by Positive Air

Positive-pressure breathing may provide protection against damage caused by intense, low-frequency mechanical vibrations such as those existing in the boost phase of spaceflight. General Dynamics/Convair scientists J. D. Brady and Dr. B. D. Newsom exposed groups of mice to ambient air and three various levels of positive-pressure breathing air, then vibrated them at 20 cps with an intensity of 7.07 root-mean-square-g, for 10 minutes. The two groups of mice with the highest levels of PPB air sustained significantly less tissue damage and mortality.

Performance Unaffected by Slow Dehydration

Another test on the ability of human subjects to withstand spaceflight stresses while dehydrated indicates that astronauts will not be affected if the water depletion occurs slowly, e.g., over a period of four to five days. In a study of nine men, who were hypohydrated through a controlled diet set up by experimenters at Ames Research Center, little change was noted in maximal isometric strength, the modified Harvard step test, submaximal O_2 intake and tolerance to centrifuge acceleration—when hypohydration was in the 0 to 4% range.

Short-Radius G Tolerance Extended

Air Force scientists at the Aerospace Medical Research Laboratories, Wright Patterson AFB, Ohio, studying human tolerance to short-radius centrifugation, have evolved a logarithmic time-duration tolerance curve showing that such centrifugation can be withstood at seven g for two minutes—and through one g in excess of two hours. This exceeds the tolerance to standard long-arm radius centrifuge acceleration, and paves the way for study of high-gradient spin systems as countermeasures for weightlessness deconditioning. The experiment was carried out with seven subjects on a 57-in. spin table with the subject supine.

OCEANOLOGY

Commerce Dept. Fleet Totals 15 Ships

Approximately 100,000 sq. mi. of the Atlantic, Pacific and Gulf of Mexico will be explored in 1966 by the 15 vessels of the newly created Environmental Sciences Services Administration (ESSA), Dept. of Commerce. The ships, under the direction of the Coast and Geodetic Survey, an agency of ESSA, will revise and update coastal water charts and explore the deep ocean. Thirteen of the vessels will be underway by early April and the remaining two will be commissioned in May and June. The working season for the ships ends in October.

Marine Tactical Data System Detailed

Air Operations Central nucleus delivered to West Coast squadron for evaluation; system transportability stressed

by Rex Pay

SANTA ANA, CALIF.—A transportable air operations central (AOC) that will bring automation into the battlefield to assist Marine Corps engagements involving high-speed aircraft and missiles has been delivered to Marine Air Control Squadron Three test site here for evaluation.

Made up of 18 helicopter-transportable huts, the AOC is the heart of the Marine Tactical Data System (MTDS) and represents an order of magnitude increase in command and control capability in the tactical arena.

Modular construction enables the AOC to operate in a simple manual mode as soon as a few of its huts are brought into a beachhead or forward area. As further huts arrive, the capability increases through various stages, up to what is very close to automatic warfare.

Typically, the AOC will be equipped with four radar systems and will provide command information to surface-to-air missile (SAM) units and to interceptor aircraft equipped with a variety of air-launched weapons. The central contains a substantial voice communications switching system and also routes ground-to-air command-data links. The AOC plus the radars and other systems it operates with is referred to as a Tactical Air Operations Central (TAOC).

At the head of the chain of command in the Marine Tactical Data System (Air) is the Tactical Air Control Center (TACC), in which data are integrated to display the overall air picture. Up to four Tactical Air Operations Centrals may report to TACC. In addition, TACC will receive information from Marine Air Traffic Control Units, which handle airstrip control, and from one or two Direct Air Support Centers (DASC).

The DASC's are concerned with close air support missions and make use of information from Marine Air Support Radar Teams (MASRT) using AN/TPQ-10 radars.

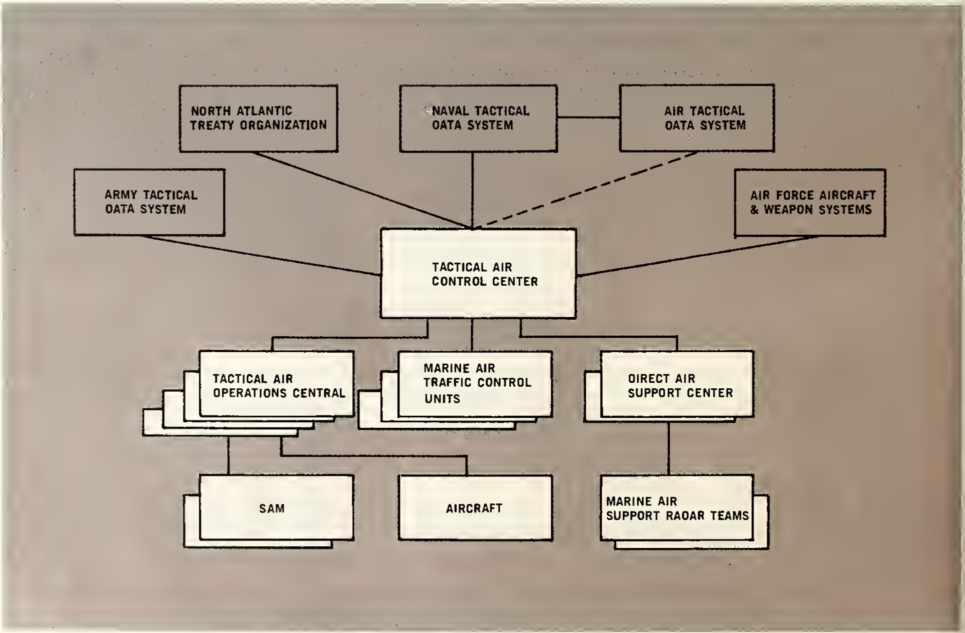
Operation of a full Tactical Air Operations Central involves 23 officers and about 220 enlisted men. Each central can track several hundred targets, supply interception instructions for aircraft, select air-to-air weapons, and coordinate the engagements of multiple SAM sites.

The OAC can also be used for air control and air defense. Lt. Col. E. A. Burns, commander of the Marine Air Control Squadron here, told MISSILES AND ROCKETS. It can be used, perhaps with fewer huts, any place there is an air control squadron. Extensive training probably will be carried out on the OAC using it strictly as an air traffic control system.

Burns said that the Marine Corps evaluation would check out the various functions of the OAC such as automatic acquisition of targets, automatic tracking, and ability to conduct intercepts.

During this work some data will be

Diagram of complete Marine Tactical Data System (Air).


NORTH ATLANTIC TREATY ORGANIZATION
NAVAL TACTICAL DATA SYSTEM
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TACTICAL AIR CONTROL CENTER
TACTICAL AIR OPERATIONS CENTRAL
MARINE AIR TRAFFIC CONTROL UNITS
DIRECT AIR SUPPORT CENTER
SAM
AIRCRAFT
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developed on maintainability and reliability. One test will be deployment to a site. Helicopter deployment may be used for one echelon, which might include one AN/UPS-1 radar and one operations hut. This could be done with one lift. A more extensive deployment would make use of 2½-ton trucks.

Later, operational evaluation will lead to development of standard operating procedures. After this, TAOC's will be delivered to the Fleet Marine Forces.

Initial performance heartening—To date the first AOC has surpassed all reliability performance requirements by a factor of two and scored repeated success in live aircraft intercepts under test conditions.

Four more centrals are in various stages of construction at the plant of the prime contractor, Litton Industries Data Systems Div. Negotiations are currently under way for more systems.

The total contract for the first production unit, including tooling, design, construction and testing, amounted to about $30 million, according to John Smith, vice-president and director of MTDS programs at Litton. An R&D unit has been under evaluation for three years.

All major decisions in the operation of the AOC flow from operators in huts that contain control and display equipment. The first AOC has five operator's huts (AN/TYA-9), each with three general-purpose command and display consoles and one communications console.

The operator at the display console has a large cathode ray tube display, a light pen, and various key-sets. With these he can select targets, rapidly evaluate the feasibility of intercept, select the best interceptor aircraft and weapon, and transmit the necessary command data for the engagement.

In each of these steps he receives substantial assistance from a general-purpose digital computer. Key to the success of the system is design of the interface between the operator and the computer.

Broad capability—Each operator can select any of 194 functions at his console. In practice he will use a much smaller number because he will be assigned a specific task such as target evaluation, SAM control, or interceptor assignment. Consoles are all general purpose so that they can be assigned to special-purpose operators as the situation demands. Or if a console should fail, another can immediately take over its task.

For basic control of the console functions, the operator has about a dozen buttons on an adding-machine type of keyboard he operates with his left hand. Above this is a second key set of 16 buttons whose function is selected by the first set. If a "test" button is pushed in the lower key set, the upper key set becomes identified by an alphanumeric display as providing a number of different test facilities. If a "track" button is pushed, the labels for the upper set of buttons change to indicate the various types of tracking function that can be selected on them. This provides a rapid and powerful way of extracting the central computer's various capabilities for assisting the operator's decision making.

The CRT display can carry a normal radar display or a television display. The broad classes of function that the chief keyset switches include various data-link operations, electronic countermeasures procedures, and fire-limit calculations.

A further set of four buttons enables the output of any of the four radar sets to be displayed upon the console.

A velocity vector can be assigned to any target to provide an estimate of position for any period up to four minutes. Intercept estimates up to eight minutes from present position can be carried out using two velocity vectors. These vectors are electroncially generated and enable quick comparisons of various interception tactics.

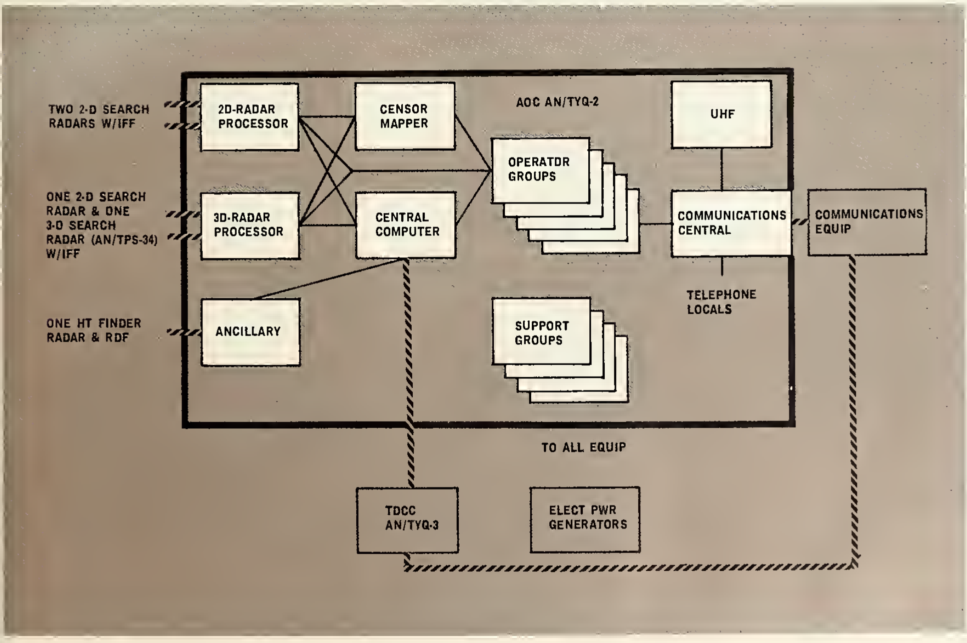
Threat evaluation—In evaluating the means of meeting a given threat, the operator is aided by alphanumeric displays above the main CRT. He can tag a target with a light pen, press an inquiry button, and read available information on the target from the upper display.

If the target is a friendly interceptor that is transmitting via a data link, the operator can evaluate its capabilities for various potential missions. To aid him in this task he can push a button to inquire intercept status. The computer will then calculate if, for example, the aircraft's fuel load and weapon complement will enable it to engage a selected target. The computer will display a simple "go" or "no go" decision.

The operator can always override this decision. He might wish to commit an interceptor to a target even though the interceptor may not have enough fuel to get back.

Using the CRT

Diagram of Air Operations Central as part of Tactical Air Operations Central.



display, the operator can select maximum ranges of 64, 128, 256, and 512 miles.

When an intercept decision has been made, the characteristics of the hostile's course and position and the course commanded for the interceptor (computer-generated) appear on a second alphanumeric display panel. This information can be transmitted to the pilot by voice channel from the operator's console, or, if the aircraft is equipped with an updata link and a display similar to that on the control console, these may be used.

When the data link mode is selected, the assignment of a target to an interceptor automatically results in the computer-generated intercept information being transmitted to the aircraft display panel. Information transmitted typically consists of headings, altitudes, weapon, and closing speeds.

Associated shelters—The other shelters in the group contribute to the capabilities of the operators' shelters in a number of specific ways.

The radar processor shelter (AN/TYA-6) acts as an automatic radar data switchboard that will select and transmit the best radar information to the general-purpose computer. There are two versions of the shelter. One processes the inputs from two two-dimensional radars; the other processes inputs from one two-dimensional radar and one three-dimensional radar. Both shelters contain IFF (identification friend or foe) decoders.

Typical radars the AOC will work with include the AN/TPS-22 two-dimensional radar, which makes use of an air-pressure-supported antenna dish of aluminized fabric, housed in a 60-ft. spherical radome, also held up by air pressure.

One of these will usually operate in conjunction with one AN/TPS-34 a three-dimensional radar yielding range, height and azimuth information. This makes use of a large dish made up of two intersecting surfaces to produce V beams. The dish can be disassembled into segments that can be man-handled for transportability. The two radars can be located up to 1,000 ft. from the huts.

An AN/TPS-37 manually controlled height-finding radar and an AN/UPS-1 radar equipped with automatic moving target indication would complete the basic radar system. The UPS-1 would be used chiefly to fill in gaps in coverage by the large radar units.

Preparation of the outputs of these radars for computer processing is carried out in the radar processor group (AN/TYA-6) by three functional logic units that operate with two magnetic drum assemblies. Rotating drums are well suited to repetitively correlating radar video to detect the presence of targets. Once a target is identified, digital rectangular coordinates are generated for it and it is signalled as an assumed friend, friend emergency, or unknown.

The equipment separates noise from targets, determines the suitablility of a target for automatic acquisition, and checks the availability of corroborating IFF video. When a number of radars are providing target information, the equipment will select the best for transmission to the central computer, changing its selection as conditions change.

The memory drum for the two-dimensional radar data processor has a capacity of 192,000 bits on 48 tracks of 4,000 bits each. It has a controllable speed range from 2,250 to 6,000 rpm, producing clock pulses over the range 150 to 400 kc. The drum has an 8.4-in.-dia. motor and 144 read-write heads.

Computer details—The general purpose computer servicing the AOC operates with 26-bit words and is also a drum memory type. It is housed in the central computer shelter (AN/TYA-5). It makes use of a 15.8-in.-dia. drum with 150 tracks, which gives a data storage capacity of 1,123,300 bits. This drum has a total of 457 heads and runs at 2,667 rpm to generate system clock pulses at 333 kc.

Made up of more than 1,800 removable circuit boards, the computer is categorized into 16 functional units. These provide automatic tracking of targets, correlation of target information, programming for the digital displays, symbolic displays, data links, teletype, height finder, and intercept computations. The ground data terminal for data-link-equipped aircraft is contained within this unit.

A complete new program for the central computer can be written onto the memory drum in 15 minutes by means of a drum fill unit mounted in a maintenance hut.

Geographical data—The other principal source of display information for the operators' consoles is the shelter that contains the geographic display generation group (AN/TYA-7). Four radar censor-mapper assemblies are installed to operate with the system's four radar units.

By use of a flying spot scanner, masks, phototubes and associated circuitry, the censor-mappers carry out a number of important functions that improve the quality of the displays.

A censor unit will define the area of responsibility to targets within the surveillance volume. It will sub-divide the volume between individual display consoles within a given group, inhibiting all other target information, including clutter, from being automatically acquired and tracked. A censor can cut out a poor return area from the main radar and insert in its place the improved returns from a gap-filler radar.

The mapper portion of these units provides background terrain maps or air corridors for superimposing on the operator's radar displays. Various scales can be selected to enable the display to show areas from 128 to 1,024 miles in diameter. Displays can be centered on the radar selected to provide the target information, or an AOC-centered display can be produced.

Inter-system reporting — Another unit within the same shelter, the cross-tell scanner, automatically picks out those items of target information that must be reported from the AOC to the Tactical Air Control Center. A similar item of equipment will also pick out those items of information that are to be reported to the neighboring TOAC—typically this will concern aircraft moving into their air space from that of the reporting TOAC.

There are three units of this type for communicating with three other TOAC's. A fifth cross-tell scanner picks out information that should be reported to the SAM site. Typically this will be any hostile target within a radius of 30 miles of the center.

In the cross-tell scanner, an additional bit is put into the 26-bit word describing the target. This bit triggers the instruction "report this." If a console operator wanted this target brought down he would touch the target on the display with a light pen, and push a button that would assign it to a particular SAM unit. When he did this the SAM unit would also receive the information it would need to engage the target.

Processing information into a form suitable for transmission to SAM sites, other TOAC's, the TACC, and other service control centers is carried out in the communications group (AN/TYA-12) hut. Two radio sets provide HF, VHF, and UHF radio links between the AOC and other centers and aircraft. A manual telephone switchboard provides voice communications between any combination of internal or external communications media. Equipment capability also includes reception and transmission of intercenter, missile-battery, and air-to-ground digital data as well as teletype data.

Like most of the other huts in the complex, this hut is 134 in. long, 76 in. wide and 73.5 in. high.

Other shelters include an ancillary hut for housing the displays and control equipment associated with radars and direction finders, a maintenance hut containing testers and equipment for repairing items such as power supplies, magnetic drum assemblies, and communications modules, and a unit test group to test and repair plug-in circuit cards and analog modules. ■

PRESSURE MEASUREMENT REPORT

CEC

REPORT NUMBER 3

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SPECIFICATIONS:

- ⊡ **Pressure Range:** 0 - 100 through 0-5000 psi absolute and gage.
- ⊡ **Rated Excitation:** 10 v d-c or a-c rms.
- ⊡ **Sensitivity:** 40 mv.
- ⊡ **Combined Linearity & Hysteresis:** within ±0.75% of full range output at rated excitation.
- ⊡ **Output Impedance:** 350 ohms.
- ⊡ **Weight:** 9 oz. max., excluding connector and tubing.
- ⊡ **Pressure Media:** Fluids compatible with Type 17-4 and 304 PH stainless steel.

The 4-354 Pressure Transducer functions reliably in all cryogenic temperature environments from –459° to +300°F. Accurate under extreme acceleration, vibration, and shock, the 4-354 has become the instrument to use to measure pressure in the cryogenic fuel lines of in-flight missiles. Its 20-mv output is compatible with millivoltmeters, galvanometers, oscilloscopes, and amplifiers, as well as other equipment.

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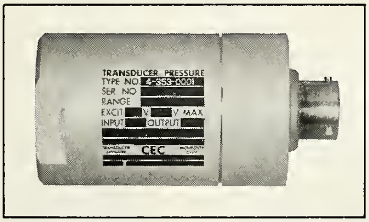
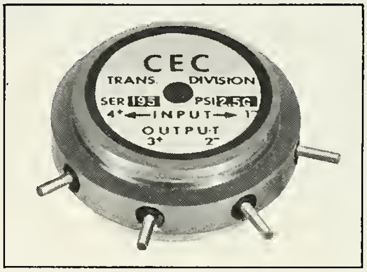
- ⊡ **Rated Electrical Excitation:** 5 v d-c or a-c rms; carrier frequency 0-20 kc.
- ⊡ **Sensitivity:** 20 mv.
- ⊡ **Linearity & Hysteresis:** ±0.5% max. of full range output.
- ⊡ **Output Impedance:** 350 ohms ±10% at 77°F.
- ⊡ **Operable Temperature Range:** –459°F to +300°F.
- ⊡ **Weight:** 5 oz. max.



The 4-353 Pressure Transducer measures absolute pressures in the low range of 0 to 5.0 psi. The smallest and lightest instrument of its type available today, the 4-353 is especially valuable in applications where size and weight are critical. Its advanced features, such as mechanical stops which permit 20 x overpressure without damage, have made this transducer an obvious choice for the measurement of airborne high altitude pressures, altitude chamber pressures, and wind tunnel pressure surveys.

SPECIFICATIONS:

- ⊡ **Pressure Range:** 0 to 5.0 psia.
- ⊡ **Standard Range:** 0 to 1.0 psia.
- ⊡ **Maximum Pressure:** 20 psia without damage.
- ⊡ **Rated Excitation:** 10 v d-c or a-c rms, 0-20 kc.
- ⊡ **Input Impedance:** 350 ohms.
- ⊡ **Sensitivity:** 20 mv.
- ⊡ **Combined Linearity & Hysteresis:** ±0.5% or better of full range output.
- ⊡ **Natural Frequency:** 2000 cps approx.
- ⊡ **Repeatability:** Within ±0.1% of full range output.
- ⊡ **Compensated Temperature Range:** –65°F to +250°F.
- ⊡ **Weight:** 7 oz. max., excluding mating connector.



The 4-325 Pressure Transducer weighs less than 10 grams, is only ¾-inch in diameter and approximately ⅓-inch high – yet it is unsurpassed for consistent accuracy and reliability in applications where small size and minimum weight are vital factors. Such applications include solid propellant engine testing, measurement of the inlet pressures of jet engines, model engine studies performed in wind tunnels and a wide range of airborne instrumentation tests. Operable temperature range of the 4-325 is –320°F to +300°F.

SPECIFICATIONS:

- ⊡ **Pressure Ranges:** 0-10 psi to 0-100 psi absolute and gage, and ±2.0 psi to ±50 psi differential.
- ⊡ **Standard Ranges:** 0-5.0, 0-15, 0-50 and 0-100 psig.
- ⊡ **Input Impedance:** 350 ohms nominal, 330 ohms minimum at 77°F.
- ⊡ **Sensitivity:** 20 mv +30% –10% for absolute and gage transducers.
- ⊡ **Linearity & Hysteresis:** ±1.0% max. of full range output.
- ⊡ **Output Impedance:** 350 ohms ±10% at 77°F.
- ⊡ **Compensated Temperature Range:** -65°F to +250°F.
- ⊡ **Weight:** 10 grams maximum.

For full information about these four unique pressure transducers, call or write CEC for Bulletin Kit #9018-X3.

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Nimbus II Will Gauge Cloud Height

Weather satellite will double coverage of Nimbus I, yield cloud altitude data by infrared automatic transmission

by William S. Beller

IF *NIMBUS II* PERFORMS satisfactorily after its expected launch late in April, meteorologists throughout the world will get "dramatic" and immediately useful information about their local cloud cover. If the satellite continues to work properly, this information will come twice a day.

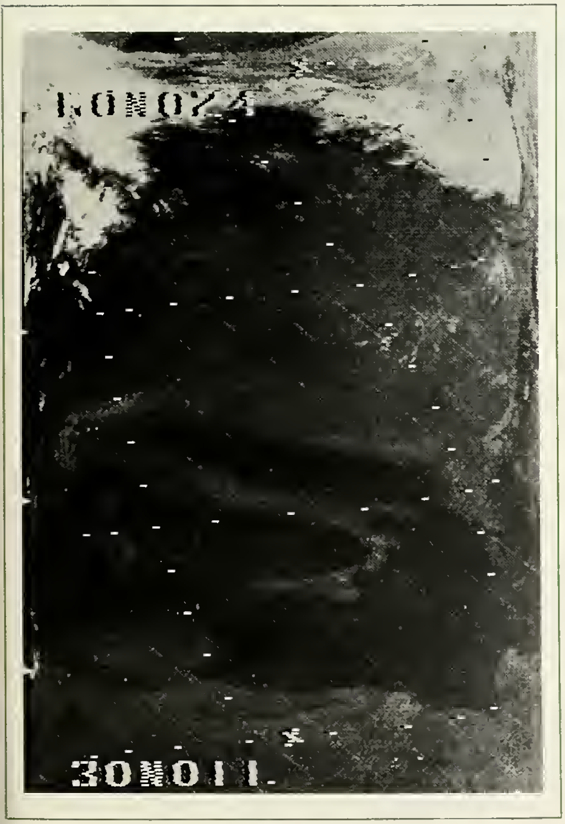
While *Nimbus I* was active, from its launch Aug. 28, 1964, until Sept. 23, 1964, when its solar-array drive system locked, it transmitted almost 2,000 cloud-cover pictures directly to weather stations all over the world. The pictures were sent through the APT (automatic picture transmission) television system (M/R, Dec. 24, 1962, p. 24).

At the same time, an infrared detection system, the HRIR—high resolution infrared radiometer—measured the temperatures of cloud tops and terrain features, recorded the data on magnetic tape, and played them out to a receiving station at Goddard Space Flight Center, Greenbelt, Md.

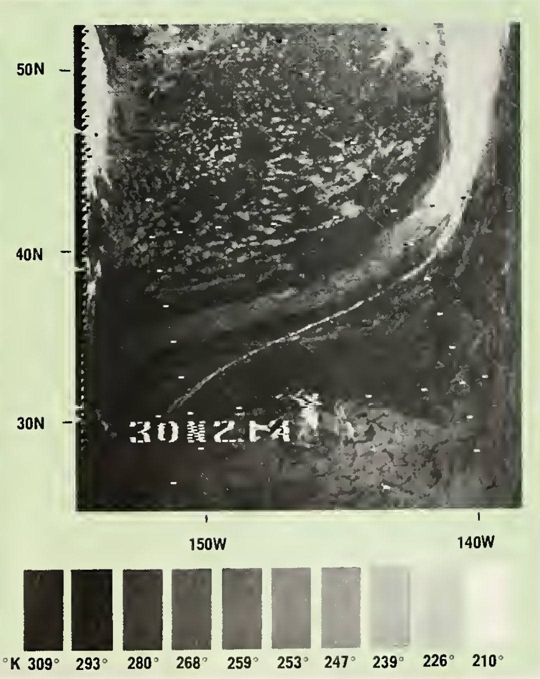
"The dramatic first of *Nimbus II*," said William Nordberg, *Nimbus* project scientist at GSFC, "is that it will not only transmit APT pictures to worldwide ground stations but also quantitative information on the height of clouds by means of IR automatic transmission."

Goddard is *Nimbus* prime contractor. General Electric makes the spacecraft structure, and is responsible for integration, test and control, and stabilization subsystems. RCA makes the daytime cameras, tape recorders, and power subsystem.

Twice the coverage—The first *Nimbus* was launched into a near-polar orbit, inclined 98.7 degrees to the equator, in order for the satellite in its trajectory to "see" the entire Earth. More-



Infrared radiation photo taken looking northeast from Africa by Nimbus I at local midnight. Below: Different shades of gray in cloud cover scanned by infrared sensor indicate different cloud temperatures and therefore different cloud altitudes. Nimbus II will double coverage provided by Nimbus I through combination of infrared capability and APT system.



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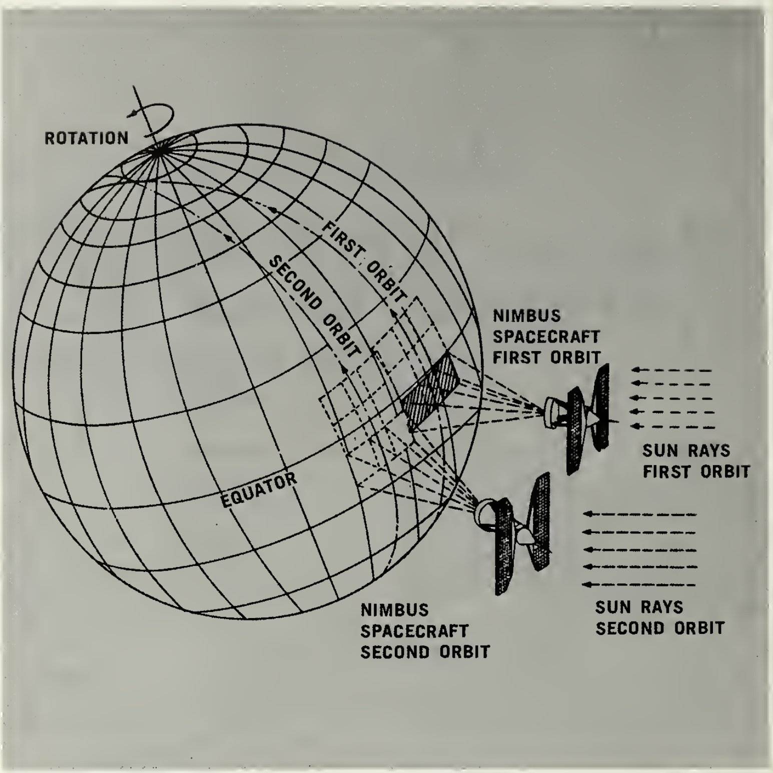


Nimbus television coverage for automatic picture transmission (APT) to ground stations. Satellite "sees" every spot on earth twice a day—at local noon and midnight.

over, the type of launch was chosen so that the Earth-Sun line lay in the orbital plane, resulting in the satellite passing over most of the Earth twice a day, at local noon and local midnight.

Similarly, Goddard will launch *Nimbus II* on a near-polar orbit. The nighttime IR pictures will give ground stations twice the coverage they had when only the APT system was operating, and will help them keep better track of diurnal weather cycles, according to Nordberg.

Cloud formations and movements in the tropics, for example, undergo strong diurnal cycles. Sea breezes, too, flow one way during daylight hours—toward land—and another during the night—toward the sea. Thus, some local users of the cloud pictures could get more than double benefit from the increased versatility of *Nimbus II*.

Weather forecasting depends not only on the appearance and track of cloud formations as seen from above but also on the height of the clouds, their temperature, the atmospheric pressure, ozone and water vapor distribution, and other factors. If a temperature lapse rate is assumed, then with this variation of atmospheric temperature with altitude known, the IR pictures will give cloud heights. Clouds with high IR radiations show up dark on the IR scan path, indicating a relatively high cloud temperature and low cloud altitude. Where the IR emanations are relatively low, the clouds appear whiter, indicating a lower temperature and correspondingly greater cloud altitude.

Long-range forecasting—Goddard's *Nimbus* meteorological satellite program is intended to point the way to getting data for forecasting weather two weeks in advance. Goddard hopes to work out the procedures through the *Nimbus* R&D program while ESSA—Environmental Science Services Administration—works out the operational means through its satellites. The first ESSA satellite, *ESSA I*, was launched Feb. 3 (M/R, Feb. 7, p. 11).

The idea is first to formulate the theoretical equations for long-range forecasting, a job ESSA is working on now. Then satellites are supposed to get the data needed to satisfy the initial conditions of the equations. Finally, the equations would be solved on an appropriate computer continuously and in time for the results still to be meaningful. The technique is known as "numerical weather forecasting."

"If it were not for the requirements of Vietnam, I believe long-range weather forecasting would have been named a national goal," Harry Press, *Nimbus* project manager, told MISSILES AND

Rockets. He indicated it still could be, involving a broadly based attack on the problems by ESSA, NASA, National Academy of Sciences, and National Science Foundation.

The next Nimbus—In NASA nomenclature, the sequence of Roman numeral suffixes attached to the names of satellites gives the sequence of satellites sent into orbit, while the sequence of alphabetical letters gives the order of satellite development. Thus, *Nimbus I* started out as *Nimbus A*. *Nimbus B* will not fly until after *Nimbus C*, so the C-version will be known as *Nimbus II* after orbit is attained; and *Nimbus B* will be *Nimbus III*. This system was intended to alleviate confusion.

Nimbus C includes two subsystems not on *Nimbus I*. The first combines the HRIR subsystem with the APT subsystem. The second is a medium-resolution infrared radiometer (MRIR), a five-channel radiometer aimed at a major experiment in studying the global heat budget.

Nimbus C also includes the three principle sensory subsystems flown on *Nimbus I*.

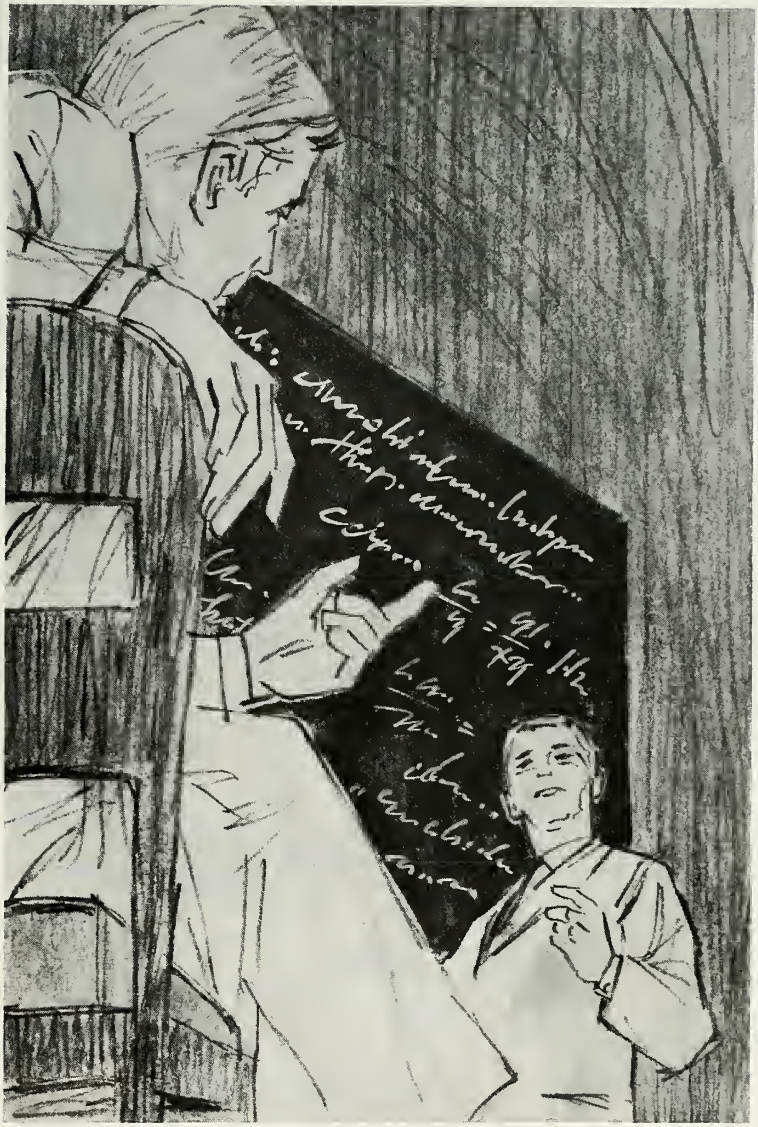
—*Advanced vidicon camera subsystem (AVCS).* AVCS provides cloud-cover pictures of the sunlit portion of each orbit with a ground resolution of about one-half mile, according to Press. The subsystem consists chiefly of a bank of three synchronized TV cameras and a magnetic tape recorder.

The three TV cameras deployed in a fan-like array produce a three-segment composite picture 107 degrees by 37 degrees, providing the lateral field of view—with two degrees overlap at the equator—needed to cover the 27-degree rotation of the Earth between spacecraft passes.

Pictures are taken every 91 seconds. The system has a storage capability for 1½ orbits of data. Each orbit yields 96 pictures covering the full daylight orbital swath. Pictures are transmitted over a 1,700-mc S-band transmitter and S-band antenna.

—*Automatic picture transmission (APT) subsystem.* The APT system operates similarly to the AVCS, but does not have a tape recorder, said Press. It consists primarily of a vidicon tube capable of long-duration storage and a very slow readout rate. The pictures are read out at a rate of 200 seconds/frame, compared to 6½ seconds/frame for the AVCS, and transmitted over a narrow bandwidth—136 mc—to ground stations. The narrow bandwidth permits ground stations to use relatively simple and inexpensive equipment.

—*High-resolution infrared radiometer (HRIR) subsystem.* The HRIR senses Earth radiation in the 3.6- to 4.2-micron region to produce cloud-cover pictures of the nighttime portion of the orbit. Because this spectral region is in



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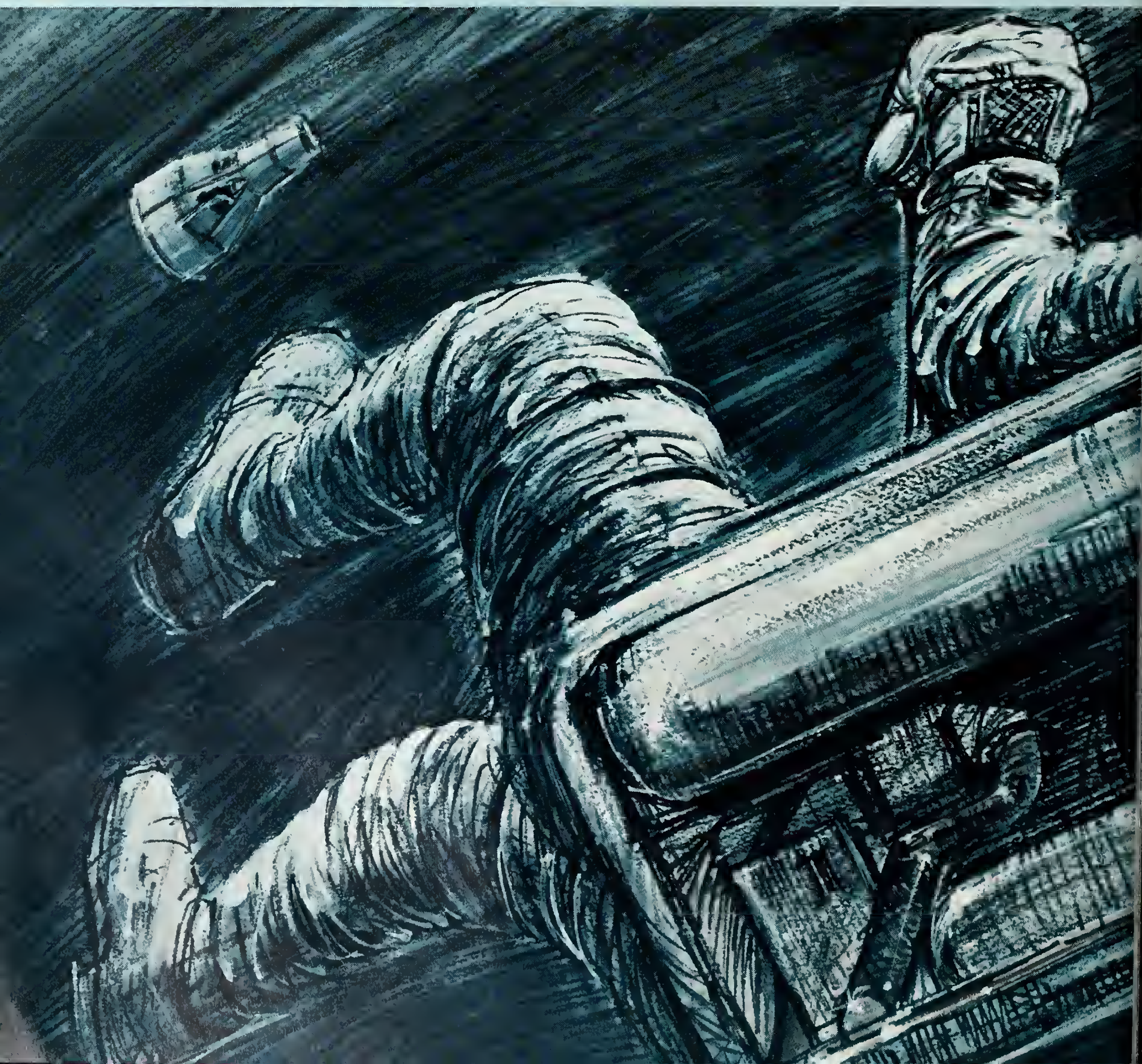

the atmospheric "window" region, it provides measurements of the equivalent blackbody temperatures of the radiating surfaces. The system has an accuracy of ±1°K and a resolution of about eight kilometers. Thus, high-resolution maps of either Earth temperatures or cloud-top temperatures are achieved.

The HRIR consists of an optical system, a photoconductive detector, associated electronics, and a mechanical drive—all enclosed in a suitable housing. In contrast to television, the radiometer forms no image, but instead integrates the energy received from the target. A picture is composed by a scanning mirror technique.

The mirror, located in the radiometer, scans the Earth from horizon to horizon as the satellite advances in its orbit. The satellite scan rate of 45. rpm was chosen to match the satellite's forward velocity in order to achieve contiguous coverage. The mirror reflects the received energy and focuses it on a mechanical chopper, which provides the necessary modulation of the energy signal. The modulated signal actuates the detector, which produces an electrical output signal corresponding to the energy signal intensity. After suitable preparation the HRIR output is recorded on the HRIR tape recorder.

The signals are multiplexed with other spacecraft intelligence, and the composite signal is transmitted by the 1700-mc S-band transmitter upon ground command. The picture is reconstituted at the ground station by a facsimile recorder and is immediately available for analysis. The analog electrical signal is also digitized to permit detailed quantitative analysis.

Scanning with MRIR—The five channels of the MRIR on *Nimbus C* will look at discrete spectral windows, and the mechanisms in the system will allow horizon-to-horizon scanning—about 2,400 miles at five miles resolution, said Press.

The bands comprise 1) the water-vapor absorption band at 6.5 to 7.0 microns—this band will give information about the atmospheric structure and water-vapor distribution; 2) the 10- to 11-micron band where the atmosphere is transparent—measurements here will give information about the Earth's surface temperature and lower atmosphere radiation; 3) stratospheric temperatures, from 14 to 16 microns; 4) terrestrial radiation, from 7 to 30 microns; 5) albedo radiation, from 0.2 to 4 microns.

APT for $200—Cost of an APT receiving station is estimated at $32,000 for a ready-made one, and around $6,000 for a do-it-yourself version. Cost of altering the speed of the tape recorder, and making other adjustments for receiving IR data is estimated at $1,000.

In the November, 1965, issue of *QST*, a monthly publication for radio amateurs, a writer claims he built an amateur station able to receive APT pictures for "well under $200 by using equipment of the kind found available in most ham shacks."

Wendell G. Anderson of station K2RNF, a staff engineer with RCA's Electronic Products Div., said that modest darkroom facilities and a tape recorder are also needed. He used "a simple home-brew picture recorder costing under $50 . . . instead of the commercial facsimile units which cost from $5,000 to $35,000."

Advanced Nimbus—*Nimbus B* will probably be launched late next year. The satellite will probe for basic meteorological data in a far more serious way than earlier *Nimbus* satellites, which in a sense are test beds for the third *Nimbus*.

Press says *Nimbus B* will probably have a radioisotope thermoelectric generator—SNAP 19—to supplement the solar paddles for power generation. The satellite will have an SIRS (satellite IR spectrometer) to concentrate on the 15-micron region of the electromagnetic spectrum; this system will help determine the vertical distribution of temperature. *Nimbus B* will also have IRIS (IR interferometer spectrometer), covering not only the 15-micron region but also the band from five to 20 microns. The 6-micron reading gives a measure of water-vapor content.

This advanced *Nimbus* will also have a GIRLS (global interrogation recording and location system) subsystem. It will be used to query and collect data from ground stations, balloons, buoys or other information gathering sources. Some NASA scientists are suggesting IRLS (interrogation recording and location system) as the more prudent acronym.

For meteorological satellites more advanced than *Nimbus B*, Press says NASA is developing sensors, such as the microwave, to look at new electromagnetic regions that will allow instruments to see through cloud layers. Spherics is another technological area, particularly useful for thundercloud detection systems. "We are also interested in determining backscatter UV," he said. "It will let us measure the vertical ozone distribution."

M. I. Schneebaum, head of Goddard's systems engineering branch, is working out an APT printout that will also tell the ground stations where and when to look for the next satellite crossing. Stations must now receive this information from literature prepared by NASA well in advance of the traverses. The necessary information for these data would be stored in the satellite. ■

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RCA Tests Thermal Energy Pipe

Molybdenum tube, developed for Air Force, uses lithium vaporization for heat transfer; gravity dependence, moving parts eliminated

by John F. Judge

A HEAT PIPE—designed to transfer thermal energy from heat sources to thermionic devices for direct conversion into electricity—is now in the practical device design stage at Radio Corp. of America's direct energy conversion dept.

The development is sponsored by the Aero Propulsion Laboratory Research and Technology Div., Air Force Systems Command. One development unit demonstrated its efficiency and reliability in a recent 500-hr. test.

The heat pipe consists of a molybdenum metal tube containing molten lithium metal. The lithium is vaporized at the heat source end of the pipe and transferred to the other end by thermodynamic action where it condenses and releases thermal energy with a negligible temperature drop.

In the 500-hr. test, the heat pipe delivered 1,000 thermal watts to the input of the thermionic unit for direct conversion into electricity. Heat pipes can be used with nuclear reactors as an alternate method to inserting thermionic converters directly into the reactor cores.

The RCA design completely eliminates moving parts. A capillary structure on the inner wall of the heat pipe returns the condensate to the boiler where the continuous cycle is repeated. Since there is no dependence on gravity, the unit will operate effectively in zero-g situations.

In operation, the pipe and the RCA-developed converter are joined using sapphire electrical insulation. F. G. Block, of RCA's thermionic converter engineering department, says this insulation allows multiple use of converters to deliver much higher useful power levels from a single heat source. The converter, RCA Developmental Type A-1198C, developed for the Air Force, is a molybdenum-ceramic unit which operates at temperatures up to 1,500°C with efficiencies up to 15%. It uses a 40-sq.-cm. emitter, delivering up to 300 watts of electrical power using cesium to enhance the operation in the arc mode.

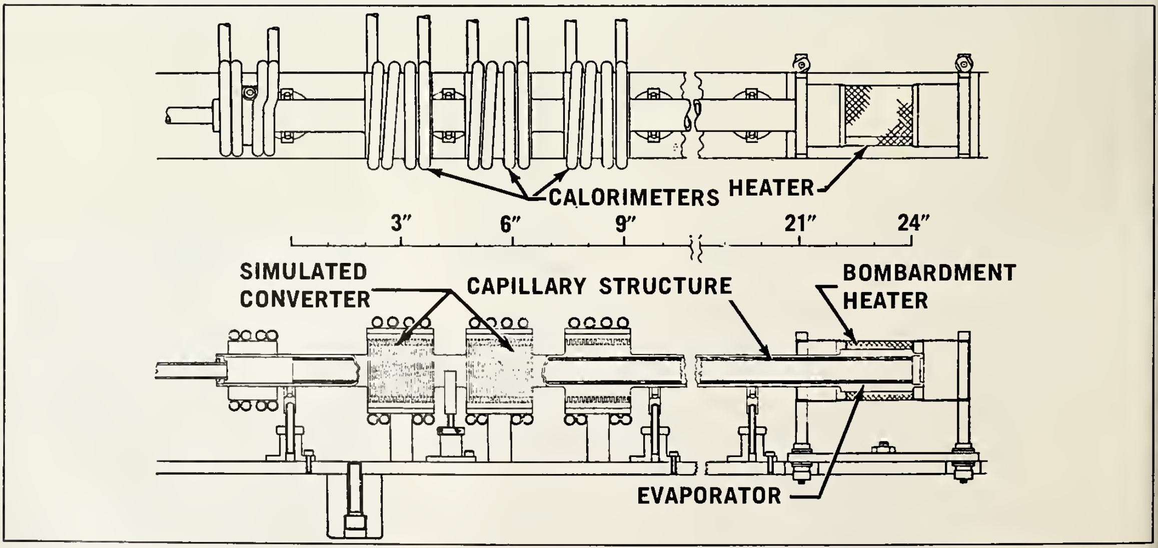
RCA has been working in heat pipe technology for over two years. During this time, devices have been made of glass, copper, nickel, stainless steel, molybdenum and TZM molybdenum. Working fluids such as water, cesium, sodium, lithium and bismuth have been tested over temperature ranges from 80° to 1,650° C.

High thermal transfer tests—One RCA investigation used a TZM molybdenum alloy pipe and lithium metal to establish that a heat pipe could transfer sufficient heat flux to operate a thermionic converter.

Three sets of radiation fins were used to simulate the heat flux required by such a converter. The first set of integral fins was placed 12 in. from the evaporator. Each set of fins represented a thermionic converter having an emitter area of 12 sq. cm. Fin-radiated heat was measured calorimetrically.

The 19-sq.-cm. evaporator was

Cross-section diagram of apparatus used by RCA scientists to detemine the ability of heat pipes to deliver enough thermul flux to operate a thermionic converter. The simulated converter is a series of fins instrumented to record the heat outputs.



heated by a thoriated-tungsten electron-bombardment heater. Three wraps of 60-mesh twill-weave screen placed inside the pipe served as the capillary wick. Power density received by the simulated converters is sufficient to drive an actual converter. Experimental results follow:

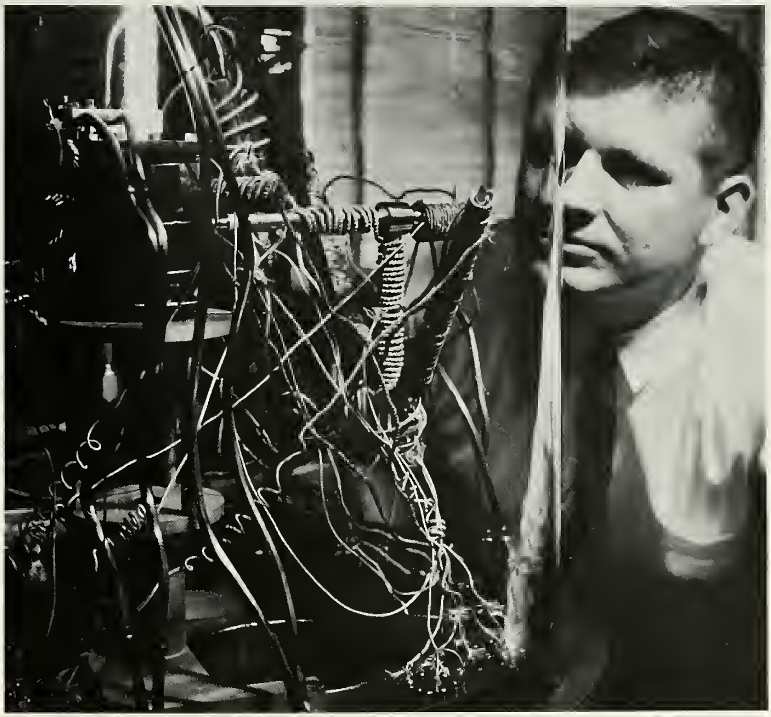
Thermal Heat Transfer Data for Lithium Heat Pipe

Operating Temperature	1200	1450	°C
Evaparalar Area	19	19	cm²
Heat-Flux Input	94.6	253	W/cm²
Tatal Heat Input	1800	4800	W
Simulated-Thermianic-Canverter Area	12	12	cm²
Heat-Flux Output	15	40	W/cm²

RCA experts note that the heat pipe is capable of transferring more power than the input of 4,800 watts shown in the table. Limitations of the bombardment power supply prevented testing to maximum capacity.

Thermal transformer—Another major testing area demonstrated the ability of the heat pipe to overcome heat flux limitations associated with heat sources such as radioisotope and fossil-fuel burners. These sources are not capable of delivering sufficient heat flux to drive a thermionic converter.

In this area, the heat pipe can be used to concentrate heat flux. The RCA experiments used a pipe incorporating a sodium working fluid and designed to



The heat pipe glows during operation in a bell jar. The development is expected to find applications in space power systems. RCA has worked with heat pipes for two years.

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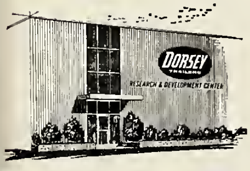

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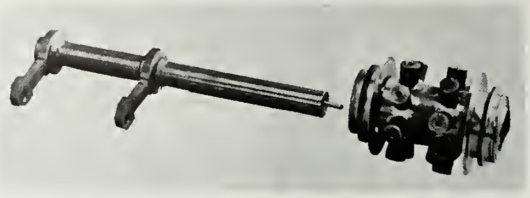

The RCA heat pipe used in the recent 500-hr. test. The pipe at left successfully transferred about 1,000 watts of thermal energy to the converter.

operate at 825° C in air.

The apparatus consists of a 125-sq.-cm. evaporator, joule-heated by the passage of current directly through the heat pipe, and a 10.4-sq.-cm. condenser tied to a water-cooled jacket through a stainless steel thermal resistor. The ratio of evaporator area to condensor area is 12:1.

RCA data acquired at two operating temperatures is shown below.

Heat Flux Transfer Data for Sodium Heat Pipe

Operating Temperature	825	775	°C
Evaporator Area	125	125	cm²
Heat-Flux Input	5	4.1	W/cm²
Total Heat Input	625	512	W
Condenser Area	10.4	10.4	cm²
Heat-Flux Output	60	44.3	W/cm²
Heat-Flux Transformation Ratio	1:12	1:12	

The values shown for power input to the evaporator are corrected—obtained by subtracting the calculated radiation and convection heat loss of the evaporator from the measured power input.

When this correction is made, a heat flux concentration of 12:1 is obtained. If not corrected, the ratio is 5:1.

The tests also show:

—that the heat pipe is capable of transferring large amounts of heat with a very low temperature gradient. In a systems application such as space, this makes it possible to separate the thermionic converter from the heat source and permits the use of lightweight radiators;

—that the heat pipe is an efficient thermal transformer, able to take the heat flux output of a source and match it with that flux required by a converter. In addition, this property flattens the temperature profile in the heat source or on the emitter surface. ■

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Dual Trip to Venus, Sun Is Studied For Pioneer

REDONDO BEACH, CALIF.—A Venus swing-by trajectory for *Pioneer* that would take the spacecraft close enough to the Sun to perform useful exploration of both bodies is being studied at TRW Systems Group here.

As the spacecraft would swing within a planetary radius of Venus, it could also carry out very similar measurements to those conducted by *Mariner,* except those requiring three-axis stabilization.

Chief advantage of the dual Venus-Sun mission would be low cost—about $5 million. Only one launch vehicle would be required.

Pioneer is a spacecraft for surveying interplanetary space. The program is managed by NASA's Ames Research Center. Four spacecraft are currently scheduled to survey a swath of space about 40 million miles wide, centered on the orbit of the Earth.

Pioneer capabilities—*Pioneer* is a spin-stabilized spacecraft and carries experiments to measure the interplanetary magnetic field, low-energy charged particles, high-energy proton and alpha particles, cosmic rays, electron density, and micrometeoroids. These same measurements close to Venus would be of considerable scientific interest. They are the same type as would be included on a *Mariner* Venus mission.

In addition, when flown in the swing-by mode, *Pioneer* would enable an improved occultation experiment to investigate the planet's atmosphere, as the spacecraft transmits at two frequencies.

These advantages would be a bonus gained in going for a spacecraft approach to within 0.4 to 0.5 au of the Sun, instead of 0.8 au, without a change in launch vehicle.

The present launch vehicle used for *Pioneer,* the thrust-augmented improved *Delta,* can put the spacecraft in solar orbit near that of Venus. By addition of a mid-course motor to the spacecraft, it can be guided close to Venus, where it will receive a gravity assist that flings it closer to the Sun.

If a more powerful booster is used, the gravity assist brings a greater bonus. A launch vehicle that would normally put *Pioneer* within 0.5 au of the Sun would, with a Venus swing-by, put the spacecraft within 0.36 au.

No proposal yet—TRW is informally discussing the mission's potentialities with NASA Headquarters and Ames. A formal proposal has not been made.

Spacecraft changes would involve addition of a mid-course motor providing about a 1-lb. thrust and weighing about 20 lbs.

Dr. Aubrey Mickelwait, *Pioneer* project manager at TRW, told Missiles and Rockets that some thermal modification of the spacecraft would also be called for because of the closer approach to the Sun. He noted that the launch opportunities for the mission were the same as those for Venus missions—every 19 months.

Pioneer is a 140-lb. cylindrical spacecraft with a diameter of 37 in. and a height of 35 in. First of the present four planned flights was launched Dec. 16 and has completed 45 days initial operation without trouble, putting the prime contractor, TRW Systems, in the "green zone" of the incentive contract. This means TRW will be earning a bonus of $2,000 per day for the subsequent 45 days of successful spacecraft operation. The bonus level then drops to $1,000 per day for the next 90 days.

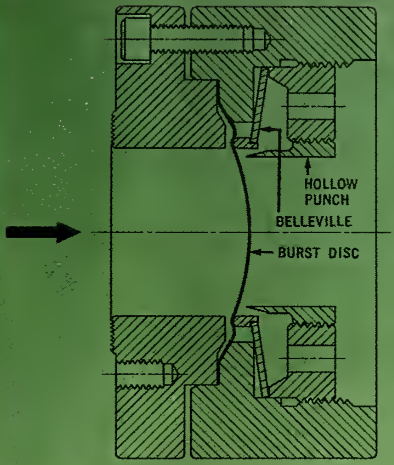
At the end of January, the first *Pioneer* was just over three million miles from Earth. Its closest approach to the Sun is expected to be 121,818,630 km June 15. The spacecraft is returning information at the rate of 512 bits per second.

Sun is stirring—Toward the end of January, *Pioneer* registered a solar storm that appeared to signal the end of the quiet Sun period of the last year or more. A solar wind velocity of 1,440,000 mph was registered. At the same time, a Stanford University experiment aboard the spacecraft also reported increased solar activity.

Stanford experimenters send data to the spacecraft from the university's 150-ft. dish at Palo Alto, Calif., and measure the effects of the electron content in the interplanetary space between the spacecraft and Earth.

Ground stations have detected a complex sunspot region that was the source of a class III solar flare Jan. 17. (Class IV is maximum size and intensity.) The effect of the increased solar wind has also been detected at the U.S. Coast and Geodetic Survey's remote magnetometer station at Castle Rock, Calif. It reported a total change in the magnetic field vector of 50 to 75 gammas per hour, compared with a normal level of four to five gammas. ■

Burst Discs to 12″ port sizes give instantaneous full flow



Burst disc assemblies from ¼″ to 12″ port sizes allow system operation within 95% of rupture ratings. Units can be supplied to operate at temperatures from −423° to + 1000°F.

Before shipment, each assembly is set to an accuracy of 1% and pre-tested for rupture without damage to the burst diaphragm.

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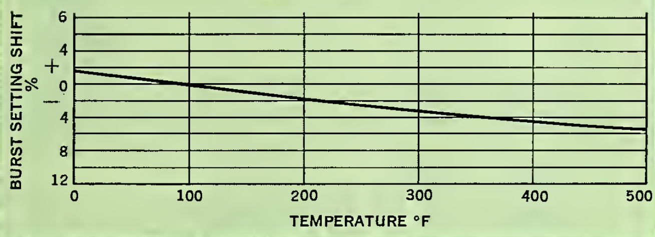
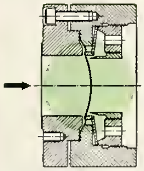
LESS THAN 2%/100°F

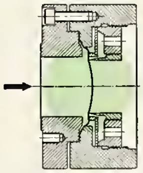


In Calmec burst disc assemblies, accuracy depends on modulus of elasticity of a spring member rather than ultimate strength; therefore, burst variation due to temperature change is very slight. Temperature compensated models with virtually zero shift in rupture setting can be furnished when desired.

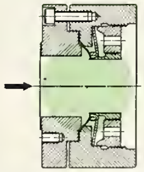
SEQUENCE OF OPERATIONS



Normal Position—Belleville spring provides partial backup of diaphragm; adjustment of spring permits accurate calibration of burst setting.



During Snap-Over — Burst diaphragm in contact with punch during snap-over of Belleville spring; pre-loading assures burst at desired pressure.



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The Industry Week

Mergers and Acquisitions

American Bosch Arma Corp., Garden City, N.Y., has acquired the assets of Sig-Trans, Inc., Amesbury, Mass. Sig-Trans, manufacturer of communications signal equipment, will be merged into ABA's Tele-Dynamics Div. . . . *Keltec Industries, Inc., Alexandria, Va., and Instrument Systems Corp., Huntington, N.Y., are negotiating a merger of the two firms. Instrument Systems produces communications equipment; Keltec is in the computer and antenna fields.* . . . Boards of directors of Controls Co. of America, Melrose Park, Ill., and General Precision Equipment Corp., Tarrytown, N.Y., have approved merger of the two firms. (M/R, Feb. 14, p. 39). . . . *The Jack Pyle Co., San Mateo, Calif., will purchase Birnbaum Sales Corp., Redwood City. Pyle is an electronic components sales representative.* . . . Warner & Swasey Co., Cleveland, has acquired The Balas Collet Manufacturing Co., also of Cleveland. The firm will be known as Balas Collet Co. and operated as a wholly owned subsidiary of W&S.

International

Amphenol Corp., Broadview, Ill., has signed an agreement with Usine Metallurgique Doloise, Dole, France, for manufacture and sale of electronic components in France. . . . *Dow Chemical Corp., Midland, Mich., has proposed purchase of majority interest in Amalgamated Chemicals, Ltd., Sydney, Australia. The offer is subject to approval of Amalgamated shareholders.* . . . Honeywell, Inc., Minneapolis, has established a new distributing firm in Spain, Honeywell, S.A. The firm is a joint venture with Omnium Iberico Industrial, S.A., Honeywell distributor for the last 13 years. . . . *American Avitron, Inc., Rye, N.Y., has opened a sales and engineering office in London, England. Stanley W. Renouf will direct the office.* . . . Dixon Corp., Bristol, R.I., and Toyo Bearing Manufacturing Co., Japan, have formed a joint company, NTN-RULON Industries Co., Ltd., in Tokyo. The firm will manufacture Dixon's modified polytetrafluoroethylene resin, RULON.

New Activities

Defense Research Corp., Montgomeryville, Pa., has established a new Photics Research Div. The division will provide services and special products in the fields of simulator input storage devices, photographic sciences and sensor research. . . . *Varo, Inc., Garland, Tex., has created two new operating divisions. The Static Power Div. will be located in Dallas North Research Park; the Power Controls Div. will be in Garland. The firm's Electronic Products Div. has been renamed the Military Systems Div.* . . . Reliable Electric Co., Chicago, has formed an electronics communication subsidiary, ComTech Corp., in Broadview, Ill. The firm will provide R&D, engineering and manufacturing services. . . . *Pinlites, Inc., has been established as an independent organization in Fairfield, N.J. It was formerly Pinlite Div. of Kay Electric Co. The firm produces microminiature lamps, micromodules and assemblies.*

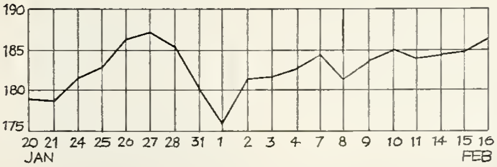
Facility Expansions

Sandia Corp., Albuquerque, N.M., plans to construct a high-temperature supersonic wind tunnel for simulation of atmospheric re-entry conditions. The High Enthalphy Arc Tunnel (HEAT) facility will be capable of producing a supersonic stream with maximum temperature of about 20,000°F and maximum velocity of 21,000 fps. . . . *Radio Corp. of America plans to increase its 1966 computer output by 75% of the 1965 total. The firm has started construction of a $3-million addition to its facility at Palm Beach Gardens, Fla.* . . . Electronic Communications, Inc., St. Petersburg, Fla., will build a 50,000-sq.-ft. addition to the manufacturing facility. Occupancy is scheduled for late spring. . . . *Hittman Associates, Baltimore R&D and engineering firm, plans to construct a 27,000-sq.-ft. facility in Columbia, Md. The firm provides services in the aerospace sciences.* . . . Entech Corp., Chicago and Washington, D.C., has opened an office in Pomona, Calif. The firm does systems analysis and engineering consulting work. . . . *Dow Chemical Corp., Midland, Mich., is considering construction of a facility to process magnesium chloride near Ogden, Utah. Preliminary plans are for plant operation in 1969.* . . . Molecu-Wire Corp., Scobeyville, N.J., plans to move to a larger facility next month. The firm manufactures superfine wire for the electronics industry. . . . *Leeden, Inc., manufacturer of fluid power components and valve control systems, has moved to a new facility in Pacoima, Calif.*

Industry Representatives

CTS Corp., Elkhart, Ind., has named NBS, Inc., of Miami, Fla., to handle its product line in Florida, Georgia, Alabama, South Carolina and parts of Louisiana. . . . *Deltime, Inc., a subsidiary of Sealectro Corp., Mamaroneck, N.Y., has appointed Walter F. Marsh & Associates, Inc., Oak Park, Ill., as sales representative in Illinois and Wisconsin.*

Missile/Space Stock Index



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STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

AIR FORCE

$21,000,000—**Avco Corp.**, Research and Advanced Development Div., Wilmington, Mass., letter contract for advanced penetration aids system.

$13,000,000—**Avco Corp.**, Research and Advanced Development Div., Wilmington, Mass., letter contract for phase 1A of the re-entry vehicle technology and observable flight test program.

$8,022,267—**Boeing Co.**, Seattle, Wash., for continued modernization of *Minuteman* missiles.

$3,113,500—**General Dynamics Corp.**, San Diego, Calif., for modification of *Atlas* missiles.

$73,000—**General Motors Corp.**, AC Electronics, Milwaukee, Wisc., for systems study of spaceborne computers.

$39,858—**Motorola, Inc.**, Semiconductor Products, Phoenix, Ariz., for seven-month reliability study of advanced integrated circuits.

ARMY

$20,000,000—**Page Communications Engineers, Inc.**, Washington, D.C., for continued work on a wide-band communications system.

$10,000,000—**Philco Corp.**, Philadelphia, contract modification for Phase II of an integrated wide-band communications system.

$3,170,125—**International Telephone & Telegraph Corp.**, New York City, to continue spare parts production for a communications system.

$1,967,878—**Avco Corp.**, Everett Research Lab, Everett, Mass., re-entry physics studies for the Advanced Research Projects Agency's Project Defender, monitored by the Army Missile Command.

$772,409—**Santa Fe Engineers, Inc.**, Lancaster, Calif., for propellant research facility at Edwards AFB, Calif.

$621,936—**Belock Instrument Corp.**, College Point, N.Y., contract modification covering industrial engineering services for simulator station, radar signal for *Hawk* guided missile system.

$201,367—**TRW Systems Group**, Washington, D.C., for implementation and initial operation of the AAFSS integrated technical data system.

$97,001—**Ryan Aeronautical Co.**, San Diego, Calif., for additional flight services in support of *Firebee* target missile.

$56,293—**ITT Corp.**, ITT Federal Labs, Nutley, N.J., contract modification for additional research study on satellite communications involving multiple-access techniques.

$51,002—**New Mexico State University**, University Park, N.M., for optical instrumentation for *Honest John* missiles.

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NAVY

$22,906,337—**Edo Corp.**, College Point, N.Y., for production of sonar sets.

$6,900,000—**General Instrument Corp.**, Hicksville, N.Y., three contracts for electronic countermeasures systems.

$3,000,000—**Massachusetts Institute of Technology**, Cambridge, Mass., for engineering support for tactical *Polaris* guidance systems.

$2,695,000—**Sperry Gyroscope Co.**, Great Neck, N.Y., for engineering services for the *Terrier* missile fire control radar sets.

$1,656,970—**Honeywell, Inc.**, Aeronautical Div., Minneapolis, Minn., for *Polaris* guidance equipment.

$577,913—**Westinghouse Electric Corp.**, Sunnyvale, Calif., for Mk 21 diaphragms for *Polaris* launcher.

$546,232—**General Electric Co.**, Ordnance Div., Pittsfield, Mass., contract modification for *Poseidon* PDP 1-C effort on fire control guidance and support equipment. Also, $40,000 for *Poseidon* guidance support equipment.

$400,000—**Raytheon Co.**, Space and Information Systems Div., Sudbury, Mass., for Phase II effort of *Poseidon* guidance system, CDP. Also, $170,000 contract modification for *Poseidon* guidance PDP effort.

$400,000—**Fairchild Camera and Instrument Corp.**, Space and Defense Systems, Syosset, N.Y., for development of a data conversion module capable of accepting signal inputs from a-c and d-c transducers and synchros and converting them to a digital form compatible with the Navy tactical data system.

$314,623—**Lockheed Aircraft Corp.**, Lockheed Missiles and Space Co., Sunnyvale, Calif., contract modification for tactical engineering services for *Polaris* missile system.

$199,200—**Hughes Aircraft Co.**, Culver City, Calif., for R&D on a missile-borne semi-active radar guidance.

$162,152—**Kaman Aircraft Corp.**, Kaman Nuclear Div., Colorado Springs, Colo., for *Polaris-Poseidon* facilities.

$105,000—**Korad Corp.**, Santa Monica, Calif., for R&D on a coherent infra-red ranging and seeker system for missile-borne applications.

$49,838—**IIT Research Institute**, Chicago, for investigation and testing of deformation and fracture mechanism in fiber-reinforced metal composites.

$46,561—**McDonnell Aircraft Corp.**, St. Louis, Mo., for conceptual flutter technical analysis applicable to guided missile configurations.

NASA

$10,000,000—**Federal Electric Corp.**, Paramus, N.J., for large instrumentation, maintenance and support at the Cape Kennedy Space Center and locations in the center's Eastern Test Range.

$1,500,000—**Heyl & Patterson, Inc.**, Pittsburgh, for fabrication, erection and testing of three flame deflectors to be used in the *Saturn* program.

$781,692—**North American Aviation, Inc.**, Space and Information Systems Div., Downey, Calif., from Ames Research Center for *Biosatellite* project flight hardware packages for *Biosatellite* experiments P-1017, P-1135 and P-1138.

$235,692—**Auburn University**, Auburn Research Foundation, Auburn, Ala., from Marshall Space Flight Center to study, develop, design, fabricate, test and deliver three models of a tracking antenna system.

$187,200—**Akwa-Downey Construction Co.**, Milwaukee, Wisc., from Kennedy Space Center for mobile cleaning facility.

$179,936—**Reynolds Smith and Hills**, Jacksonville, Fla., from Kennedy Space Center for preparation of operations and maintenance manuals for the mobile launchers and related equipment.

$97,760—**TRW, Inc.**, Redondo Beach, Calif., from Headquarters for study of an orbiting *Radio Astronomical Observatory*.

$89,577—**Cornell Aeronautical Lab**, Buffalo, N.Y., from Marshall Space Flight Center for *Saturn V* shroud and fin interference free-static aerodynamic investigation.

$80,412—**Hayes Internatonal Corp.**, Birmingham, Ala., from Marshall Space Flight Center for experimental hypervelocity impact research study.

$79,132—**GCA Corp.**, GCA Technology Div., Bedford, Mass., from Manned Spacecraft Center for Earth-based lunar atmosphere investigation.

$72,430—**Sylvania Electric Products**, Mountain View, Calif., from Marshall Space Flight Center for design, development and delivery of high-frequency tracking phototubes.

$55,300—**TRW, Inc.**, Redondo Beach, Calif., from Manned Spacecraft Center for accelerator modification equipment.

$53,775—**United Aircraft Corp.**, Hamilton Standard Div., Windsor Locks, Conn., from Headquarters for experimental and analytical study of cardiovascular mechanism control loops.

$39,500—**General Electric Co.**, Missile & Space Div., Philadelphia, from Manned Spacecraft Center for study of optimum soft-landing trajectories.

INDUSTRY

$1,300,000—**Garrett Corp.**, AiResearch Manufacturing Div., Los Angeles, from **General Dynamics Corp.**, Fort Worth, Tex., for wing flap actuation systems for the F-111.

MISCELLANEOUS

$3,662,000—**Irwin & Leighton, Inc.**, Philadelphia, from **Cornell University**, Ithaca, N.Y., for construction of a laboratory building for use with the world's most powerful circular electron synchrotron.

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names in the news

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Robert E. McDonald: Named president of Sperry Rand Corp.'s Univac Div. **Gerald G. Probst** will succeed him as vice president and general manager of the Defense Systems Div.

John J. Myers: Appointed vice president of research and engineering for the Electronics Div. of General Dynamics. Prior to joining the company, he was vice president for radiation and marine systems and research and development at North American Aviation, Inc.

Col. M. Dooley: Assigned to the Army Missile Command as project manager of the *SAM-D* air defense system now under development. He was with the *Nike-X* project in Washington, D.C.

Charles Kezer: Named vice president and director of engineering of Litton Industries' Potentiometer Div. **Albert A. Romagnoli** has been named vice president and director of operations for the division.

Byron D. Frankenberger: Elected vice president of engineering for Conic Corp. He has been responsible for engineering and design of the firm's products for more than four years.

Donald W. Fuller: Appointed vice president in charge of marketing for the Redcor Corp. He was formerly vice president, engineering. **Phil H. Mounts** and **George E. Olenik** have been named vice president, operations, and director of marketing, commercial and industrial systems, respectively.

John A. Wolfe and **Robert Naiman:** Named divisional vice presidents within Itek Corp.'s government systems organization.

W. A. Boone: Named president of the International Telephone and Telegraph Corp.'s Fluid Handling Div. He will direct nationwide activities of the enlarged division and will be responsible for its expansion into international markets.

James M. Maddock: Elected to executive vice president of Dyna-Therm Corp. He will retain his post of secretary-treasurer.

Saul Kurlat: Named vice president and general manager of the Physical Sciences Div. of Technical Operations Research. In his new position, he will be responsible for overall management of the division.

Robert N. Vandeland: Elected vice president of marketing of Dynair Electronics, Inc. He is vice chairman of the Industrial Div. of the Electronics Industries Assn., as well as chairman of the closed-circuit television section.

James N. Ebright: Elected secretary of Aerojet-General Corp. He has been assistant secretary and chief counsel of the company and will continue to serve as chief counsel.

John P. Lynn: Elected vice president of American Welding & Manufacturing Co. He has been general manager of the company since 1961 and will continue to serve in this capacity.

Fred M. Borwell: Elected a vice president of Allis-Chalmers. He is general manager of the company's engine-material handling division.

William F. Martin: Named vice president, manufacturing of Cadillac Gage Co. **Robert J. Meldrum** has been named treasurer of the company.

Norman E. Miller: Elected a vice president of Atlas Chemical Industries, Inc. He has been company controller since joining the firm in 1956 and will continue in this office.

Russell M. Braga: Elected executive vice president of Standard Pressed Steel Co. He will be responsible for division operations and corporate staff planning.

Joseph H. Famme: Appointed vice president of engineering of Rohr Corp. He was vice president of aircraft programs for Convair Div. of General Dynamics.

Dr. Richard J. Goldberg: Elected vice president of engineering of the Houston-Fearless Corp. He was formerly vice president of the systems research division for Technicolor Corp.

missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY

published weekly by
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FEBRUARY

1966 National Meeting of the American Astronautical Society, El Cortez Hotel, San Diego, Calif., Feb. 21-23.

17th Pittsburgh Conference on Analytical Chemistry & Applied Spectroscopy, Penn-Sheraton Hotel, Pittsburgh, Feb. 21-25.

Symposium on Interdisciplinary Aspects of Radiative Energy Transfer, sponsored by the Space Sciences Laboratory of General Electric Co., the Joint Institute for Laboratory Astrophysics of the University of Colorado, the National Bureau of Standards, and the Office of Naval Research, Sheraton Hotel, Philadelphia, Feb. 24-26.

MARCH

National Conference on Space Maintenance & Extravehicular Activities, sponsored by the Air Force Aero Propulsion Laboratory Research & Technology Div., and the Martin Co., Robert Meyer Motor Inn, Orlando, Fla., March 1-3.

10th Scintillation and Semiconductor Counter Symposium, sponsored by the Institute of Electrical and Electronics Engineers Nuclear Science Group, Shoreham Hotel, Washington, D.C., March 2-4.

The American Institute of Aeronautics and Astronautics Technical Committee Plasmadynamics Conference on Plasma Measurements and their Interpretation, U.S. Naval Postgraduate School, Monterey, Calif., March 2-4.

Third Annual Southeastern Symposium on Government Contracts, sponsored by the Mid-Florida Chapter, National Contract Management Assn., Cherry Plaza Hotel, Orlando, Fla., March 3-4.

Electrical Engineering & Operation Conference, sponsored by the Pacific Coast Electrical Assn., Sheraton Palace Hotel, San Francisco, March 3-4.

Conference on Space Economics, sponsored by the American Institute of Industrial Engineers, Canaveral Chapter, Ramada Inn, Cocoa Beach, Fla., March 5.

American Congress on Surveying and Mapping and American Society of Photogrammetry Convention, Washington Hilton, Washington, D.C., March 6-11.

Geometric Optics Seminar-in-Depth, sponsored by the Society of Photo-Optical Instrumentation Engineers, White Sands Chapter, Hilton Inn, El Paso, Tex., March 7-8.

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Once and Future Things

THE ADMINISTRATION'S record $57.2-billion Dept. of Defense budget for Fiscal 1967, together with more than $14 billion in supplemental defense funds requested for the current fiscal year, leaves little doubt that there is a booming military market for the products of this industry.

There is also the warning by President Johnson and top DOD officials that further escalation of the war in Vietnam may make it necessary to ask Congress for even larger defense funding.

It is all too easy in these circumstances for the industry to forget that its true promise for the future lies not in the military field but in the market for advanced technology, including the needs of the defense establishment.

In the past, industry planners have sought all manner of panaceas whenever defense spending fell off, only to rush back to the military bandwagon at the onset of the next crisis.

Certainly, the military requirements of Vietnam must be met and this industry has a duty and obligation to meet them. But it must not do so at the cost of its early probings into other areas where advanced technology can be of benefit to society. In the long run, although defense and space will remain major markets, opportunities for expansion must be found in oceanology, transportation, data handling, and still other fields in which the requirements for systems management and advanced technology are high.

To fully realize its growth potential, the industry must recognize that these are not stopgaps to be examined whenever defense spending drops and abandoned when the demands of war take up the slack.

President Johnson has said, "The economic cost of Vietnam poses no unbearable burden on our resources." This is true, as true of the industry as it is of the nation. This industry has the resources to fulfill Pentagon needs, support an ambitious space program—and still explore these areas of new potential.

It is accurate to say that these other markets for advanced technology do not yet offer the return on investment to be found in defense and space work. Yet the firms which are today's industry leaders are the ones sufficiently farsighted to invest time and money in new technology when the end of World War II decimated the market for military aircraft. There is equal opportunity for firms willing to take the same long view today.

The fact that budget requests in some of these areas did not leap forward as they might have without the depressant of a huge military budget should not discourage those who have taken either firm or tentative steps in these directions.

The study of high-speed transport for the Northeast corridor between Boston and Washington, D.C., will go forward, as will sufficient spending on oceanology to continue exploration of this promising field. A number of aerospace firms have put substantial amounts of company funds into new oceanology units. It is to be hoped that this trend will continue, since exploration of the undersea environment is so closely akin to space exploration in its demands on technology.

The state of California continues to seek funds for the interesting series of socio-economic studies which have as their main benefit the determination of just what the aerospace industry can contribute to solving such problems as air and water pollution.

A temporary slackening in Federal funding for some of these fields should not be taken as a permanent lack of interest, even in the face of a Vietnamese war which could drag out for many years. That the surge in military spending is temporary can be realized by contemplating what the DOD budget would have been without Vietnam spending.

There are too many social and economic problems which this country must meet, whatever happens in Vietnam. This industry is in a position to solve many of these. Obviously, a solution to the Southeast Asian conflict would release more budget funding for other purposes, including a more extensive space program.

BUT EVEN WITH a continuing drain in Vietnam, these other requirements must be met—and can be met in a country of such vast economic capabilities.

That President Johnson has an appreciation of the true competence of this industry was evident in his special message to Congress on the space program.

"As our space program continues," the President said, "the impact of its developments on everyday life becomes daily more evident. It continues to stimulate our education, improve our material well-being and broaden the horizons of knowledge. It is also a powerful force for peace.

"The space program of the United States today is the largest effort ever undertaken by any nation to advance the frontiers of human knowledge. What we are discovering and building today will help solve many of the great problems which an increasingly complex and heavily populated world will face tomorrow."

The President's words are a charter for the future of the industry. Never before has any nation so depended on the ability of one industry to meet its challenge. Never before has the opportunity for an industry been so great.

There is no denying that increased military spending is a shot in the arm to the industry's economic well-being. But it must be remembered that much of the work to be done for the future actually lies elsewhere.

William J. Coughlin

Space-Age Boeing Openings for Engineers and Scientists

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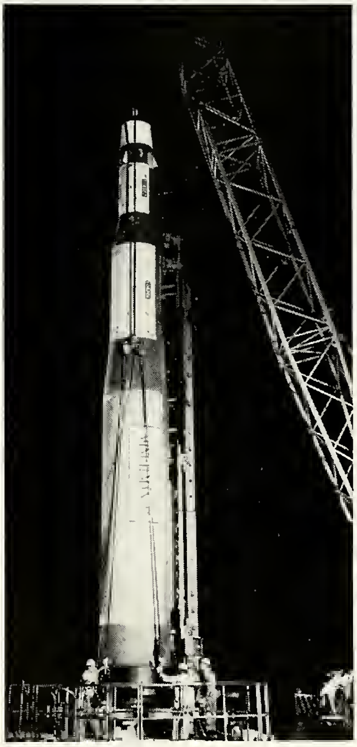

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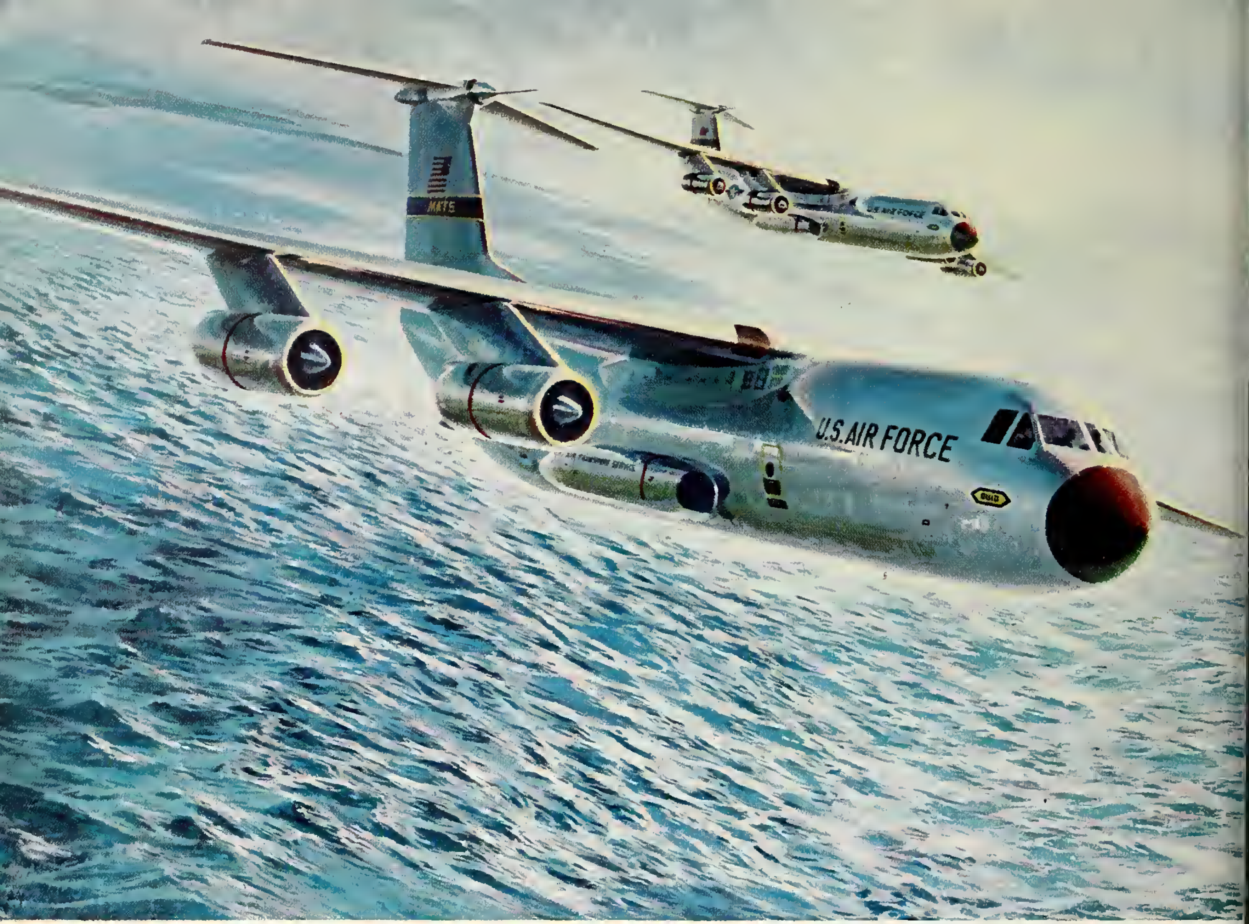

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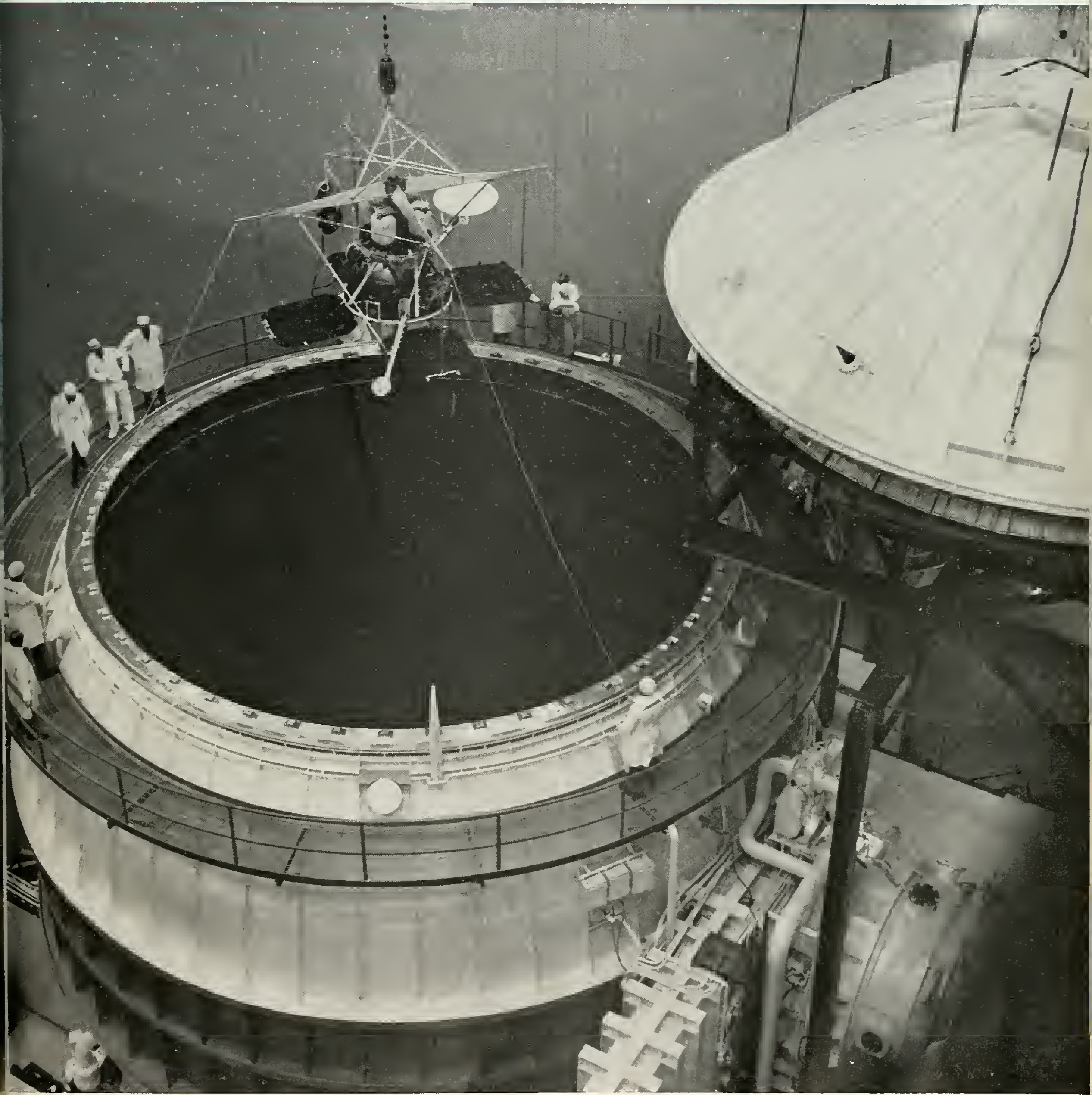

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THE COVER

Ground test Lunar Orbiter spacecraft enters environmental chamber at plant of prime contractor Boeing Co. Spacecraft is beginning a three-week real-time simulation of lunar photo mission. Temperatures will range from —300° F to 250°F. First Lunar Orbiter launch is set for mid-1966.

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J. B. Montgomery, President

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letters

Defense Space Spending

To the Editor:

I just finished reading your Feb. 7 editorial, entitled "The New-Speak Budget."

Without expressing any opinion regarding the merits of your sarcasm, I know you would want to have any major factual error pointed out. I suggest that your statement that "military space funding is down about 15%" and that this presents a "discrepancy" with the assertion in the budget that "Defense space spending will continue at about the 1966 level" is misleading and is in error in part. The budget figure for space funding or new obligational authority is not down 15%, but rather is about 4.2% less than the FY 1966 figure. This is a reduction of $72.8 million from the $1,693.5 million of FY 1966. It is true that the estimated expenditures for space in the Department of Defense are at approximately the same level for 1967 as for 1966. Actually, the estimate shows an increase of about $10 million. As you know, new obligational authority and expenditures are the same only by coincidence and in a program as complex as that of space, would not be expected to be the same. Certainly, this is true of any well run private business as well as of the Government, and cannot rightly be considered a fair basis of criticism.

Dr. Edward C. Welsh
Executive Secretary
National Aeronautics
and Space Council
Washington, D.C.

To the Editor:

Congratulations on the Feb. 7 editorial. It's comforting to know that at least one writer doesn't roll over and play dead before that avalanche of gobbledygook. And there are times when a sense of humor seems about all that's left.

Henry Still
Manager, Public Relations
Northrop Ventura
Newbury Park, Calif.

To the Editor:

Congratulations on your editorial of Feb. 7. You succeeded in demonstrating with specific examples the deceitful double talk contained throughout the FY '67 budget. I have read numerous articles alluding to that character in its content but all without concrete evidence. Your editorial removed the question from the realm of opinion and placed it in the realm of fact, thus striking another rare blow for responsible journalism.

C. Walker Putney
San Jose, Calif.

To the Editor:

Your editorial of Feb. 7 is great. I await your editorials each week and find them for the most part worth reading. This editorial though is truly outstanding.

D. Thostenson
Unitrode Corporation
Burlingame, Calif.

Luna Photo Problems

To the Editor:

Is a picture worth a thousand words? Today we'd better say the Moon shots need a thousand words. The Soviets should be complimented on their excellent achievement of a soft landing on the Moon and their photographic attempts. But the interpretation of pictures should be made by those persons who have all the facts.

MISSILES AND ROCKETS' composite picture on pp. 12-13 of the Feb. 14 issue shows artifacts in the black sky that have been produced somewhere in the electrical or communication record playback process. Most likely these have been produced on the space vehicle. The state of the art of electronic components and system engineering has not progressed, even in this country, to the perfection desired. Heat, cold, vacuum, low-level signals, electronic components, limited dynamic range, shock, structural change, antenna optimization, etc. can reduce the quality of Moon shots.

The Moon shot is a challenge to the best photographer. High contrast with changes from back-lighting to front-lighting in the absence of atmospheric attenuation is only part of the problem. To perform this task automatically without overloading the sensitive electronic devices is even more difficult.

If the artifacts in the *Luna 9* probe pictures are discounted, the actual surface detail may not be identified any further than the major black and white areas. The picture could be comparable to the *Ranger* shots.

Kenneth R. Mercy
Falls Church, Va.

$100-Million Typo

To the Editor:

In your article "NASA Cutback Perils Moon Schedule" (M/R, Jan. 31, p. 25), it was stated that the Office of Space Sciences and Applications' 1967 budget request was trimmed to $661.4 million—over $200 million below last year's $783.2 million total. I believe the statement should be: "over $100 million below," since the exact differences between the two budgets is $121.8 million, which is further supported by the individual divisions detailed in the article.

Encapsulated in an environment of constant bickering about totals being off by as much as $1, it is refreshing to detect an error of this magnitude.

L. D. Messacar
Chief of Financial Control
ETR Operations
General Dynamics/Convair
Cocoa Beach, Fla.

Once and Future Things

To the Editor:

Amen! to your Feb. 21 editorial. Let's keep our eye on the main chance.

W. T. Schultz
New York

Lockheed doesn't try to teach old materials new tricks.

To help men and machines survive the harsh environments encountered in space and re-entry back to earth, Lockheed has developed a unique approach to the technology of materials. It is tailoring and inventing materials to meet specific space and re-entry environments rather than using old materials better suited for land, air or ocean applications.

The Lockheed tailoring approach takes many forms. Materials made from filaments of silica and carbon—able to bear loads and resist moderate temperatures up to 3000 degrees F through a special Lockheed bonding technique. Charring materials—able to bear loads and endure extreme heat and radiation caused by nuclear blast. Thin coatings which solve the surprising problems of refractory oxidation on the border between atmosphere and space. New alloys possessing great strength at high temperatures—alloys which are literally invented through a unique Lockheed process involving microparticles of metals and oxides.

These Lockheed tailoring techniques are also finding use closer to home. They can produce stronger turbine blades and bearings, paints with remarkable longevity, and lighter materials for supersonic transports.

Materials approaches such as these are only one measure of the technological competence of Lockheed: a corporation dedicated to the conquest of new worlds through innovation.

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The Countdown

WASHINGTON

Lucky Seven Manned Flights for Apollo?

If everything goes well, the U.S. could land a man on the Moon after a total of only seven manned *Apollo* flights. This would include four with the *Saturn IB* booster and only three with the *Saturn V*. According to NASA man-rating procedure, *Saturn V* will be man-rated after two successful unmanned flights. Then two successful manned Earth-orbital flights will man-rate the entire vehicle for the lunar landing.

Luna 9 List Troubles LEM Planners

NASA officials are disturbed at the news that the *Luna 9* spacecraft listed some eight degrees after its initial soft landing on the Moon. While scientists estimate that the bearing strength will be sufficient for *Surveyor* and *Apollo* landing gear, planners are concerned at the hazard such movement might create if it occurred during the final stages of the countdown for the ascent from the Moon of the Lunar Excursion Module.

Supplemental Debate Drags On

Consideration of the FY 1966 supplemental Defense bill promised to continue into this week in both houses of Congress, as debate raged over Vietnam policy. The House Armed Services Committee version of the bill is the same as that of the Senate, which reported it out of committee earlier, but adds $49.7 million for construction. Both would give the Administration the full $3.4 billion sought for procurement, and $151.6 million requested for research and development.

First Apollo Crew Choice in 2-3 Months

NASA expects to pick the crew for the first three-man *Apollo* flight in two to three months. They will be picked from a pool of 11 astronauts now studying the *Apollo* spacecraft and mission.

Agena Tests Pressed with Eye to Gemini 8

Ignition and mission-simulation firing tests on the *Agena* engine at the Air Force's Arnold Engineering Development Center are now expected to be finished by March 10. Malfunction tests will then be completed before the scheduled March 15 liftoff for *Gemini 8*. The tests on the Bell Aerosystems engine were renewed on Feb. 24. The ignition tests—5-sec. firings—were to continue for three days. A five-day clean-up period will precede mission-simulation tests beginning late this week.

Still, Travel Is Broadening

Luna 9 does not appear to be as sophisticated as *Surveyor*, NASA officials have told Congress. While its landing instrument capsule is reported by the Soviets to weigh 220 lbs., the rest of the "bus," which was jettisoned sometime prior to landing, probably took it to well over the 600-lb. lunar-landing weight of *Surveyor*. NASA experts also said the petal configuration shown in photographs probably was used to right the capsule in the proper orientation.

Making Up for AOSO Trimming

The *Advanced Orbiting Solar Observatory* program, which now appears to have little hope of resuscitation, has so far cost $30 million, of which $20 million is non-recoverable, NASA told Congress. In lieu of an *AOSO*, studies are being made of ways to enhance the *Orbiting Solar Observatory (OSO)* program, such as a more accurate pointing system, larger and longer instruments, and a method of achieving offset pointing. In addition, NASA is putting $3-4 million of its FY '66 funds into study of the design of a stable platform and sensors for the *Apollo* Applications Program for telescopic experiments.

INDUSTRY

Rucker Apollo Centrifuge Accepted at MSC

A $10.5-million three-man centrifuge built by the Rucker Co., Oakland, Calif., has been formally accepted at the Manned Spacecraft Center at Houston. The device, with a 12-ft.-dia. spherical gondola, 50-ft. arm and controls, will be used to train *Apollo* crews under g-loads simulating launch and re-entry environments. The gondola, which depressurizes to simulate altitudes up to 125,000 ft., can be whirled up to a maximum 30 g for as long as three minutes, or 20 g for as much as 30 minutes. A 6,700-hp d-c motor, built by Westinghouse Electric Corp., drives the centrifuge. First test since the facility became operational subjected *Gemini 8* extravehicular equipment to a simulated *Titan II* launch environment.

Grumman Hires Piccard for Ocean Work

Grumman Aircraft Engineering Corp. has signed up the services of Dr. Jacques Piccard and his Lausanne, Switzerland, laboratory for oceanographic and ocean engineering work. One of the first projects will use Piccard's planned PX-15 100-ton mesoscaph, possibly in an underwater study of the Gulf Stream current from Florida to Nova Scotia.

Seven Answer Comsat Corp.'s RFP

Comsat Corp. has received seven responses to its RFP for design studies of a multipurpose satellite. Responding were TRW Systems, Hughes Aircraft, RCA, Lockheed Aircraft, Philco Corp., Boeing and General Electric. As of last week's deadline, no foreign firms had submitted proposals. Comsat said in its RFP that one or more four-month study contracts would be awarded. Main objective of the proposal is to define a flexible satellite design adaptable to various functions, including simultaneous transmission of various types of communications between ground and aircraft and ship to shore. The proposed satellite would be launched into synchronous orbit, weigh no more than 2,300 lbs. at launch and have a minimum life in orbit of five years.

INTERNATIONAL

New French Missile Frigate Launched

The Duquesne, a 5,700-ton frigate to be armed with *Masurca* anti-aircraft and *Malafon* anti-submarine missiles, has been launched at Brest for the French Navy. The ship is equipped with a three-dimensional CSF/CGE/SNERI radar, the heaviest unit of its kind ever built for a French vessel.

Satellite-Photography Unit Reaches Norway

A complete satellite-photography unit has arrived at Tromsö, Norway, in a USAF Cargomaster. Photographic observations will be made jointly for the U.S. Coast & Geodetic Survey and Norway's Geografisk Opmåling. The camera is a Baker-Nunn type, and the Tromsö station will be one of a worldwide chain of similar observatories.

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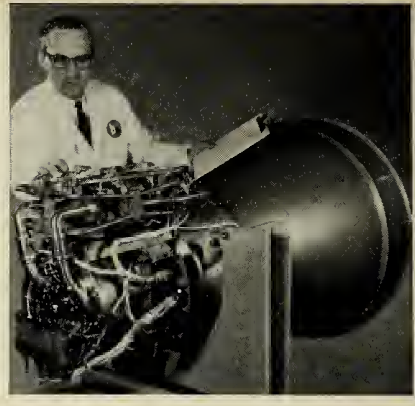
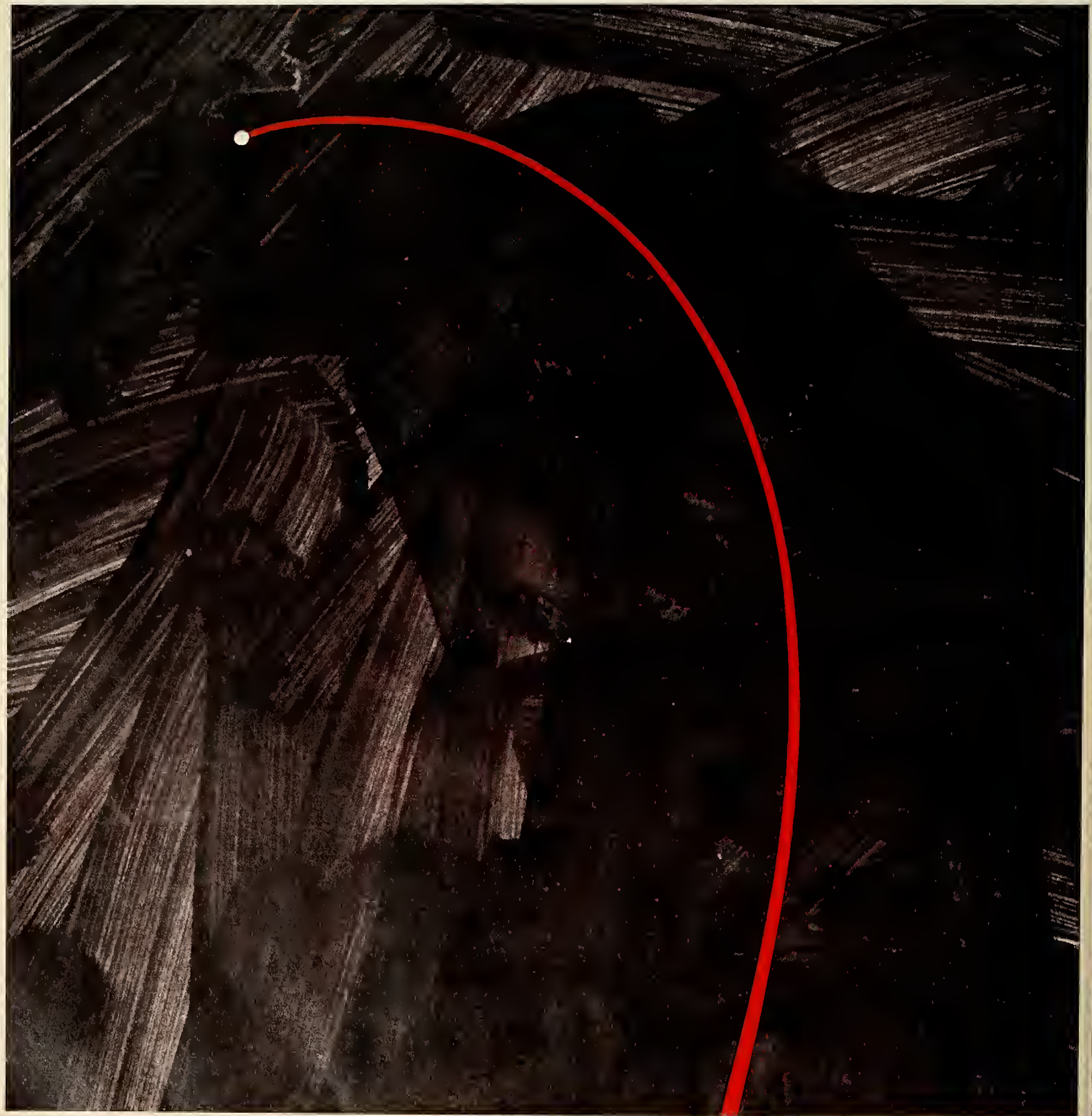
BELL AEROSYSTEMS—A textron COMPANY Buffalo, New York





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The Missile/Space Week

Voyager Plans Dismay Congress

Congressional dismay at the manner in which NASA is going about preparations for the much-postponed *Voyager* program is evident in hearings now under way in the House Space Committee.

In sessions chaired by Rep. Joseph Karth (D-Minn.), members of the Subcommittee on Space Sciences and Applications have voiced their opinion that NASA is not putting enough effort into the solution of the major problems that have delayed a landing on Mars until at least 1971.

Karth, who has led committee panel investigations on *Ranger* and *Surveyor* programs that led to changes in those programs, expressed his own fear that *Voyager* is going the same way as previous programs, and that it promises to reach "a high-water mark" of difficulty for NASA if the trouble spots are not attacked early.

In opening sessions of the committee's hearings on the Fiscal Year 1967 budget, there was evident dissatisfaction with the $10-million funding level, as well as with the decision to proceed with three contractors rather than deciding now on one.

Deputy Associate Administrator Edgar Cortright told the group that requests for proposals on the *Voyager* capsule for Phase B contracts are expected to be issued in October, leading to the signing of several contracts for studies to be conducted in the spring of 1967. RFP's would then be issued for the Phase C contract in the fall of the next year.

Funding of the spacecraft portion of the *Voyager* program amounts to $3.5 million through FY '66, Cortright said, with no funds actually going to the capsule portion. FY '66 spacecraft bus funds will also cover work done in FY '67, but the capsule will receive funding of $2 million.

Cortright estimated that FY '68 funding for *Voyager* would reach $7 million for the spacecraft and $9 million for the capsule. The committee criticized this low level of funding in the light of the probable ultimate cost of the program of more than $1.5 billion.

The committee also was critical of NASA's decision not to have a probe capability in the 1969 *Mariner* shot. Committee questioning brought out the fact that Ames Research Center supports this idea, as well as Cortright himself. (See related story, p. 18).

Such a probe, Cortright said, would give much better information on the Martian atmospheric pressure and density, but the $30 million or more cost associated with it was the prime reason for ruling against the idea.

Further breakdown of improvements and changes in the *Surveyor* program account for necessity to reprogram an extra $27.5 million in FY '66 funds (M/R Feb. 14, p. 15).

These include upgrading of the transmitters, klystron power tubes, telemetry calibration, tape reader reliability and strengthening of electronic part qualification tests.

Funds for Block II *Surveyor* were outlined for the committee as running to $96.3 million for the spacecraft and $45 million for launch vehicles for the three missions.

The *Orbiting Astronomical Observatory* program was yet another project on which NASA admitted to some faulty initial thinking. Now 2½-3 years behind schedule, *OAO* problems were said by Cortright to be the result of naivete at the complexity of the program during the original planning.

Space Benefits Seen Widening

The massive investment in technology and manpower created by the *Apollo* and other space programs can be turned to handle pressing problems derived from anticipated population growth on Earth.

For example, says Dr. Peter A. Castruccio, director of advanced space programs at IBM Federal Systems Div., satellites can survey the world from space, pinpointing tillable land in minutes, not months.

Staple crops can be examined by satellites using infrared techniques to detect diseases invisible to the naked eye at close quarters. The seas can be mapped, isolating concentrations of fish and edible seaweed.

The growing consumption of water could be offset by using satellites to map snow fields and glaciers. In addition, Castruccio says underground rivers should be detectable from space by measuring the tiny differences in soil temperatures above them. Such streams are estimated to have 3,000 times the water present in all known rivers.

Other fields, such as weather control and geological surveys searching for fuel and minerals, can be handled from space. Castruccio detailed the concepts at the American Astronautical Society meeting in San Diego last week.

Shots of the Week

France successfully carried out the first all-French space launch on Feb. 17, putting a gold-plated, 41.8-lb. *D-1A (Diapason)* satellite into orbit from the Hammaguir base in Algeria aboard a *Diamant* launch vehicle.

French scientists said the shot was a complete success, achieving an apogee of 1,710 mi. and perigee of 312 mi., period of 118.14 min. and inclination of 34.04 degrees from the equator. Mission of the *D-1A* is to send back data on the Earth's magnetic fields and check French tracking stations.

- The Soviets on Feb. 22 launched *Cosmos 110*, carrying two dogs named Veterok and Ugolyok on what the Tass news agency described as a mission "to conduct biological studies." Tass said the apogee was 561 mi. and perigee 185 mi. The launch came two days after the orbiting of an unmanned *Cosmos 109*.
- A *Polaris A-3* was launched successfully Feb. 17 from the nuclear submarine Lewis and Clark, submerged about 18 mi. off Cape Kennedy.

Comsat Airs Home TV Plans

Direct broadcast of television programs from satellites to home receivers appears to be at least 10 years away, Dr. Spencer W. Spaulding, manager of Comsat Corporation's Systems Analysis Division told the 1966 National Meeting of the American Astronautical Society.

He said that Comsat has drawn up nominal characteristics for a multipurpose satellite distributing network television programs to local stations and also providing ground-aircraft voice communications.

If required, this could come into service in late 1967 or early 1968, said Spaulding. It would be a synchronous satellite with 10 kw effective-radiated power for 6 to 12 television channels and 4 kw ERP for 6 to 12 simplex voice channels for aeronautical services. Local television

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stations would require 20- to 30-ft. antennas. Airline terminals would require 42-ft. microwave antennas; aircraft would use 0-db gain VHF antennas.

An *Atlas-Agena* or *Titan-Agena* launch vehicle would put the satellite into orbit.

Satellite channel capacity would depend on how early the system was implemented. Comsat Corp. plans to go ahead with a 4-month study program based on the proposals it has already received for a multipurpose satellite.

Aim will be to meet all foreseeable needs through 1975.

Comsat Corp. is also actively considering a satellite restricted to aeronautical services for the Atlantic in mid-1967. The corporation expects to have further discussions with television networks and civil aviation users, to decide how these new services can best be implemented.

The three-day AAS meeting in San Diego on practical space applications focused on useful applications of space technology.

In the keynote address, Harry J. Goett urged that the space program should continue to provide the opportunity for experimenting with new ideas in orbit.

Goett, director of advanced technology at Philco Corp., Western Development Laboratories, said that opportunity to experiment was required chiefly in the area of instrument technology.

Lunar Dust To Be Fabricated

Selected materials will be ground in ultra-high vacuums by National Research Corp. in an effort to simulate the dust assumed existing on the lunar surface and produced by meteorite bombardment.

The primary aim of the $50,000 NASA-Langley Research Center study is to generate data on the dust's bearing strength. NRC experts will analyze the dust to determine the range of particle sizes and shapes, and measure the density, compressive strength and shear strength.

Materials under consideration include basalt, olivine basalt, olivine and pumice. The study marks the first production of the dust under extreme vacuum conditions.

Republic Predicts a Profit

Republic Aviation Div., Fairchild Hiller Corp., expects to gross more than $100 million in sales and show a profit in 1966, its first full year of operation, according to Thomas Turner, marketing manager at Republic Div. This contrasts sharply with the situation in 1964, when Republic Aviation Corp., before it became part of Fairchild Hiller, grossed more than $297 million in sales but lost more than three dollars a share.

F-105 modification and aft fuselage manufacture for the McDonnell F-4 gives Republic Div. most of its current income. "This gives us the financial base we need to go after new major aerospace systems contracts," Turner told MISSILES AND ROCKETS.

Aerospace Work To Aid Oilmen

Existing aerospace industry technology can be of assistance to offshore oil drilling companies very soon, if not immediately, in several areas, it became apparent at the Offshore Exploration Conference (OECON) in Long Beach, Calif., last week.

Aerospace spokesmen made it clear at the conference that they see the movement of the petroleum industry to offshore locations as possibly the best immediate opportunity to apply aerospace know-how to the field of oceanology.

Observers attending the meeting felt that its potentially most fruitful aspect was that it assembled aerospace representatives and offshore drilling experts for joint study of how to meet the oilmen's looming problems—the need for remotely controlled subsurface devices, command and control of unmanned equipment, faster transportation of crews over longer distances, safe and efficient maintenance of these crews in an increasingly hostile environment, methods of exploring this environment for new oil reserves, and ways to improve economics of the business to allow for expansion.

Two examples of aerospace developments offering very near-term, if not immediate, benefits are instrumentation electronics and explosive devices.

Bunker-Ramo Corp., Canoga Park, Calif., reported on an extensive program of testing standard electronic components to determine effects of high hydrostatic pressures, an effort carried out in connection with the firm's work for the Navy.

B-R's Glenn W. Gerlach noted that a recent anti-submarine warfare project used a protective pressure vessel that weighed 1,360 lbs. for an electronics package that weighed only 60 lbs. He said that "it is not hard to imagine the many advantages that would result by finding components that operate at great

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ocean depths" and are inherently capable of withstanding severe pressures.

While the Bunker-Ramo work is far from completed, Gerlach said, tests have confirmed that satisfactory off-the-shelf components can be found. "It is possible to produce conventional circuits for underwater applications with little or no pressure protection."

Dr. David A. Lee, of Mechanics Research, Inc., El Segundo, Calif., reported that many of the explosive devices originally developed for aerospace use have now been qualified for underwater use. These include explosive igniters, bolts and guillotine cutters, and linear-shaped charges. Such equipment has proved to be completely reliable after three years' submergence at 20,000 psi in seawater. Potential applications include such equipment as underwater propulsion rockets.

Discussing developments in offshore exploration systems, C. G. Welling, of Lockheed Missiles & Space Co., called attention to the intensified activity in ocean survey and exploration in recent years and the "expectation that this growth will continue at an ever-increasing pace."

Developments in oceanographic instruments have been relatively slow because of the comparatively low budgets available to scientists, Welling said. "As we go into deeper waters, new systems are needed," he observed. "Again, it is apparent that the lack of improved tools can delay developments."

Space 'Weathermen' Urged

"The ultimate goal of weather modification and control may be realized only if man himself is placed in a Space Meteorological Lab" says Sidney Sternberg, vice president and general manager of Electro-Optical Systems.

The ability and bandwidth of transfer of information between experiment and experimenter cannot be duplicated by unmanned observations. Man's capabilities and deductive logic in pursuing the unknown in defining relationships that had not been previously recognized is beyond the scope of instrumentation.

Sternberg told the national meeting of the American Astronautical Society that weather control may be the most significant contribution of the entire space program, and if this is possible with a man in the system, then the U.S. should start working in this direction as soon as possible.

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McNamara Outlines MOL Schedule

Secretary's defense posture statement also stresses hike in tactical war procurement; opposition to A-ICBM system softens

by Michael Getler

DEFENSE SECRETARY Robert S. McNamara, in his annual defense posture statement to the military committees of Congress last week, reports that "design definition, systems integration, development of specifications and determination of firm cost proposals" for the Air Force's *Manned Orbiting Laboratory* "are scheduled for completion during this spring and summer, after which contracts will be awarded for full-scale development of hardware."

The Secretary's statement, following up presentation of an FY '67 budget which called for spending considerably less money on *MOL* in the coming fiscal year than had been forecast earlier by DOD, provided the first official indication of the *MOL* timetable available in several months.

MOL will receive, with Congressional approval, $159 million of a total $1.621-billion military space request.

In summing up his view of current world affairs for the five-year U.S. defense projection, McNamara said "the focus of the U.S. defense problem has shifted perceptibly toward the Far East. Overt aggression . . . in Europe . . . seems increasingly unlikely as long as we maintain our military strength and unity."

The translation of the Secretary's views, in terms of military expenditures in FY '67, is reflected in large increases in procurement of conventional ordnance and weapons systems for tactical warfare, a considerable expansion of defense research and engineering into the problems brought forward by the war in Vietnam (but without any major increase in funding at this point), and at least a softening of opposition to deployment of an anti-ballistic missile system in the face of a Chinese ICBM threat in the mid-1970's.

A summary of the new defense posture statement, highlighting those areas which were not covered during the earlier presentation of the FY '67 defense budget, follows. Details of the FY '67 budget were reported in a MISSILES AND ROCKETS Special Report published Jan. 31.

Strategic offensive forces—Secretary McNamara's views on the adequacy of U.S. strategic forces for both assured destruction of enemy forces and damage limitation to the U.S. were also outlined in detail late last month (M/R, Jan. 31, p. 10) before a House Armed Service subcommittee investigating already announced cutbacks in the B-52 and B-58 bomber force.

The Secretary took that opportunity to discuss the entire strategic posture, arguing that the bomber force could not be analyzed properly unless presented within the context of the total strategic retaliatory force including missiles.

Strategic defensive forces—All 14 of the Back-Up Interceptor Control (BUIC-II) centers augmenting the highly vulnerable SAGE air-defense network will be operational by April 1. Modification to a BUIC-III configuration will begin in FY '67, and eventually 19 of these enlarged centers will be operational in FY '69.

DOD evaluation and flight-test program will continue towards a possible decision to build a new manned interceptor and advanced missile and fire control system, the ASG-18/AIM-47. The YF-12A three-aircraft flight-test program will get $20 million in FY '67, with an additional $10 million for the F-12 program.

For airborne warning and control of aircraft and missile continental defense forces, the DOD has requested $3 million in FY '67 to initiate contract definition for development of the prototype AWACS aircraft (M/R, Jan. 10, p. 16). An additional $12 million is requested for the overland radar portion of the project.

To extend ballistic missile early warning time beyond that provided by BMEWS, DOD has also asked for an additional $23 million for development of over-the-horizon radar. Some $42 million has already been spent.

The FY '67 request for *Nike-X*, including continued testing of *Sprint*, the new longer-range *(DM15x2)* exoatmospheric interceptor, a new family of modular radars, and construction of test facilities at Kwajalein Is., is $447 million. An additional $119 million is requested for the related Project Defender re-entry measurements and ABM techniques program.

Despite the emergence of a potentially effective area defense against either Chinese or Soviet missiles made possible by development of the exoatmospheric version of *Nike-Zeus*, there is still no need for a decision to deploy against either threat, according to the Secretary.

Though the development effort should be pursued with "the greatest urgency," the Secretary believes that "no decision should be made now to undertake an all-out damage limiting effort against the Soviet threat" . . . and that "since we do not now believe the Chinese Communists could deploy any significant ICBM force before the mid-1970's, no production decision on that account is needed at this time."

The Secretary, whose views on *Nike-X* were also reported in detail to the House subcommittee last month (M/R, Jan. 31, p. 10) added in last week's statement that "an initial operational capability would be possible for a U.S. system within a relatively few years after a production and deployment program is initiated."

McNamara also stated that evaluations will be conducted over the next several months on interceptor test data and radar evaluations made with the *HIBEX* high-acceleration missile and the associated *HAPDAR* phased-array radar, part of an experimental hard-point missile target defense.

General-purpose forces—*Army*—Army air defense missiles will get major attention. Funds are included for conversion of more *Hawk* fixed batteries to self-propelled units, which actually increases the fire-power of each battalion.

Increase in the procurement of the gun/*Chaparral* forward-area defense system, and increased efficiency of the self-propelled *Hawk*, will also permit some reduction in reliance upon the shoulder-fired *Redeye* missile, according to DOD. *Hawk* will also benefit from a new improvement program to be funded initially in FY '67.

The *Lance* surface-to-surface missile, initially intended as a replacement for *Honest John* and *Little John* missiles, is now also viewed as a more effective substitute for some tube artillery, so that the currently proposed *Lance* force structure is viewed only as a minimum level.

The Army's major new missile development is the *SAM-D* (M/R, Jan. 3, p. 12, and Jan. 31, p. 17).

—*Navy*—Funds are requested for development of a new *Point Defense Surface Missile System* based upon the Navy's *Sea Sparrow* concept (M/R, Oct. 25, p. 9). Test results have been encouraging thus far. Originally intended for combat ships, the system probably will also be expanded to cover amphibious and auxiliary ships which have no other air-defense system.

Analysis of the ASW problem indicates that a total of 64 first-class nuclear attack submarines (SSN's) will be needed over the currently projected five-year period. Forty-seven are now available, and six were funded in FY '66, leaving 11 more to be built in the future. Five will be started in FY '67.

In other ASW developments, Navy will also add new SH-3A/D ASW helicopter units to attack aircraft carriers.

In addition to the Navy's two new guided missile destroyers which will carry the new *Standard Missile/Tartar-D* combination (M/R, Jan. 31, p. 17), the Navy during FY '66-'70 will modernize or convert 22 guided missile ships, including four cruisers, at a total cost of $600 million.

The Navy's *Phoenix* missile, intended for the trouble-plagued F-111B, is apparently back once more in its own problems. After a host of early technical problems and cost overruns, top defense officials described the missile as back on the track. The posture statement, however, now says that "these problems in the missile and fire control system have not as yet been fully resolved and some delay in the F-111B program appears inevitable."

The Navy decision on whether or not to buy the F-111B will not be made until December.

—*Air Force*—The defense review also revealed the expected purchase of the Navy's *Walleye* TV-guided glide bomb by the Air Force (M/R, Jan. 31, p. 9). In addition, the Air Force reports it proposes to buy substantial quantities of *Rockeye* and *Sadeye* special-purpose ordnance, and *Shrike* anti-radiation missiles.

Major new AF aircraft buys include the Navy-developed A-7 attack aircraft (augmented with afterburner), an expansion of procurement of the F-4, which had been expected to taper off in FY '67, a reconnaissance version of the F-111, and first quantity production of the OV-10 COIN aircraft to replace the currently used O-1 aircraft.

Research and Development

Space projects—In addition to *MOL*, DOD will spend $62 million in FY '67 on a variety of defense communications satellite projects. IDSCP, the initial network, will be placed into orbit over the next several months, with the system moving out of R&D and into operational status in mid-1967. (See M/R, Jan. 31 special report on Space Communications for a complete report on military space communications plans, including the development of a new tactical comsat system also indicated in the posture statement.)

The $62 million includes $36 million for the space segments of the projects, $18 million for ground terminals, $5 million for the shipboard installations, and $3.5 million for DCA management.

The Navy will get $21 million for operation of its navigational satellite system, with most of the funds applied to operating costs. About $3 million will be used for system improvements, including preparation of an almanac for predicting orbital path to simplify the satellite's on-board memory circuits.

About $7 million has been requested for space geodesy work, $2 million for the Army and $5 million for the Navy's supporting ground-tracking network.

Titan III will account for a $66-million request in FY '67, with $26 million of this going for completion of the development of a seven-segment 120-in. solid motor strap-on and an improved first-stage liquid engine required for the *MOL* program. Total cost of the *Titan III* program through FY '67, including $84 million in construction, is now pegged at about $955 million.

In other space projects, DOD has requested $16 million for the *PRIME* portion of the *START* program, designed to demonstrate return from orbit of data capsules using maneuverable re-entry. Four flights using *Atlas* vehicles on suborbital missions will be made from the Western Test Range.

Advanced Space Guidance has also been singled out for $2 million, covering definition of guidance and control requirements for advanced manned orbital and re-entry operations, improved horizon sensing, star tracking, and landmark navigation techniques.

Solid rocket engine development within DOD will get $2 million for demonstrating the 156-in. segmented motor concept. All funding of the 260-

Third 260-in. Firing Plan Announced; Second Test Succeeds

NASA has announced that there will be a third firing in the half-length 260-in.-dia. solid motor test series during July, 1967, with a goal of 5 million lbs. of thrust and 80-sec. burning.

The announcement preceded by a few hours the firing of an 80-ft.-long, 260-in. solid rocket motor at Aerojet-General Corp.'s Dade County, Fla., plant on Feb. 23. Igniting precisely on schedule at 7:00 p.m. EST, the motor fired for a total of 126 secs. and reached the planned thrust of 3.6 million lbs. Spokesmen for Aerojet, the prime contractor, said actual data received during firing exactly matched the predicted data.

A. O. Tischler, director of chemical propulsion at NASA's Office of Advanced Research & Technology, said the firing was "a tremendous success."

New plan—For the third half-length 260-in. firing, for which Aerojet will also be the contractor, the plan is to refurbish one of the current maraging steel cases and couple it to a new nozzle.

The third firing will involve Aerojet's omni-vectoring nozzle concept, which means that the unit will be "buried" in the motor only to that extent necessary for the test. The omni-vector idea is amenable both to total nozzle movement, as in gimballing, and to liquid thrust vector control.

The new motor will have a propellant composition based in a burning rate equivalent to that necessary for a full-length 260-in. powerplant. The nozzle will increase in throat diameter from the present 71 in. to between 82 and 90 in., depending on the burning rate selected. Slivers will also be added to the new motor to improve the thrust-termination section of the operation. The buried nozzle will involve modifications to the aft dome of the massive case.

The thrust level will fall between 4 and 7 million lbs., depending on the propellant composition. Thrust is not the primary purpose of the third firing, which will be conducted in the nose-down condition at Aerojet's Dade County plant.

No decision has yet been made as to the nozzle subcontractors. Some competition may develop because of both design and materials changes.

Continuation of the large solid program at this level should keep the Aerojet Everglades complex busy for some 16 months, and add more definitive information to the big solid booster files.

in. rocket motor has been taken over by NASA.

DOD has also requested $15 million to continue its liquid rocket engine R&D. The two major efforts involve an advanced, modular design, storable liquid rocket engine with improved payload-to-weight ratio, and a high-performance cryogenic system capable of multiple restarts.

The space budget also includes $39 million for improvements to the AF's SPACETRACK and Navy's SPASUR satellite tracking networks, and $59 million for satellite control facilities. The latter includes a new permanent tracking site at Guam.

About $8 million of the DOD space budget is included in the *Vela* nuclear detection satellite project. The overall DOD involvement in nuclear detection will cost $239 million.

Research—FY '67 request totals $417 million, up $27 million over last year. Defense research in the engineering sciences will get $119 million, $95 million is for physical sciences, $57 million for environmental sciences. Biological and Medical get $34 million, $13 million go to Behavioral and Social Sciences, and some $36 million for the in-house Independent Laboratory Research Program.

Exploratory development—Total spending will amount to $1.063 billion.

Most of the Army's $232-million share will be directed at improved close-support for front line troops.

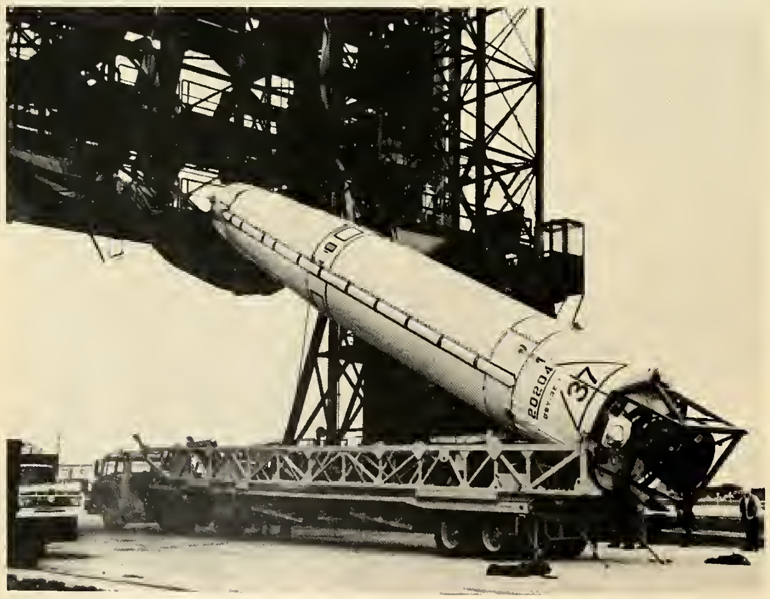
About 40% of the Navy's $304-million request will be for new "sea warfare systems." About $80 million will go for improvements to surveillance and navigation systems, and some $44 million for new ship design concepts such as the Albacore type of submarine hull.

About half of the Air Force's $316 million request will be applied to space-related investigations.

ARPA's exploratory development budget will total $211 million, including the $119 million for Defender.

Advanced development—Highlights of the total $835-million package requested include a small but important initial Navy funding ($2 million) for the *Advanced Surface Missile System.* The project (M/R, Jan. 3, p. 12) will remain in this very early development stage for another year, with development of *SAM-D* proceeding on a more rapid scale and certain to affect future *ASMS* progress.

The Navy also disclosed plans for new missile development, including $2 million to flight-test the Army's *Lance* missile from a ship as a "Landing Force Support Weapon" (M/R, Oct. 18, p. 21).



Launch Vehicle for ESSA II Is Erected

Delta launch vehicle No. 37 being erected at Cape Kennedy for launch of ESSA II satellite, the second of the Environmental Science Service Administration's TIROS operational system meteorological satellites. ESSA is part of the Commerce Department. It will use the satellite system to obtain global meteorological data on entire sunlit portion of Earth daily and relay data back. ESSA II was to carry two Automatic Picture Transmission (APT) cameras into circular, 860-mi.-high orbit, with a period of about 113 minutes. ESSA II launch was set for Feb. 25.

The Navy also requested development funds for *ARM-1,* the follow-on radar homing missile to replace *Shrike.* An additional $4 million has been requested to extend the *ARM* technology beyond the *ARM-1* weapon.

About $98.5 million of the Navy's overall ASW RDT&E budget of $355.4 million for ASW is concerned with the advanced development category. A small portion of this, about $2 million, is for a new effort, "inshore undersea warfare," which will explore detection techniques to counter small underwater craft and frogmen in close areas.

The Army's advanced development effort is heavily oriented towards V/STOL and new surveillance aircraft efforts, with about $72 million requested in FY '67 by all three services to continue to probe the stability and control problems exhibited by V/STOL craft.

The Army will also spend $4 million for new prototype aircraft suppressive-fire hardware systems, $4 million for continued work on automatic data systems for the field Army, and some $7 million for the Limited War Laboratory.

Air Force funds in this category are also heavily weighted on the V/STOL technology program; however, an additional $10 million has been requested for work on advanced filament composites, and $8 million for advanced air-to-surface missile technology in an attempt to develop all-weather systems and improve fair-weather missile operations.

Engineering development—Within this category, the release of the posture statement confirmed the fact that a contractor had been selected for the Army's new *Medium Anti-Tank Weapon (MAW)* and that development would begin in FY '67 (M/R, Jan. 10, p. 15).

It was also disclosed that two *TOW* anti-tank missile systems are expected to be delivered late in FY '67 for use in an expanded development testing program.

The Navy revealed plans to develop a possible follow-on to the *Sea Sparrow* concept to provide "a significantly better system for the future." The system reportedly may draw on portions of the Army's now-cancelled *Mauler* program.

Funds were also requested by the Navy for a new ASW rocket-boosted ballistic missile compatible with the *ASROC* launcher and fire control system but exhibiting greater range. Contract definition and engineering development are both planned for FY '67.

Another $8 million in Navy funds was requested for a second-generation *Snakeye* retarded bomb, and for *Fireye,* an improved fire bomb. ■

Saturn IB-Apollo May Finish Early

Seven-mission plan depends on success of initial flights, Saturn V availability; outlook brightens for three-man launch this year

by Hal Taylor

Cape Kennedy—NASA now is hoping to conclude the *Apollo/Saturn IB* program after a total of seven flights and only four manned missions.

The plan for early termination of the program was learned here as the first shot in the series was delayed by poor weather conditions from Feb. 23 to Feb. 25 at the earliest.

High winds and driving rain made it necessary to defer the launch, for which good conditions are a requirement. However, the launch of an *ESSA II* satellite on a *Delta* booster was still scheduled for Feb. 25 (see photo, p. 16).

The premiere flight, *A/S-201,* was designed to flight-test both the *Saturn IB* booster—with its 2-million-lb.-thrust first stage and the 200,000-lb.-thrust second stage—and the *Apollo* Command and Service Modules by sending the spacecraft to a peak altitude of 300 mi. and then ramming it back into the atmosphere at a speed of 10,000 mph.

If successful, it will almost certainly mean that the space agency will make this country's first three-man spaceflight by the end of the year.

In discussing the program's future, Dr. Joseph Shea, director of *Apollo* spacecraft development at the Manned Spacecraft Center, told Missiles and Rockets that the hoped-for early end of the program depends on the availability of the *Saturn V* booster, as well as success of the *Saturn IB* missions.

"We plan to end the series at *Apollo-207* if the *Saturn V* is available on schedule. If not, we will probably continue with *Saturn IB* flights for the *Apollo-208* and *209* missions," he declared.

If the *A/S-201* mission is successful, the second shot in the series is expected to be launched early this summer. The spacecraft for the mission, designated Spacecraft 11, is currently in final fabrication and checkout at North American Aviation, Inc.'s Space and Information Systems Division, prime contractor for the Command and Service Modules. It is scheduled for delivery to Cape Kennedy in 6 to 8 weeks.

Heating test—The *A/S-202* flight will test the peak heating load during a shallow re-entry path into the Earth's atmosphere. It will be launched on a super-circular suborbital flight travelling ¾ of an orbit before the Service Module engines are fired to send it to the planned impact area in the Pacific Ocean.

It will be possible to conduct the launch almost simultaneously with *A/S-202* in early summer because it will use a different launch pad.

It will go from launch pad 37 at Cape Kennedy, while the first two missions will be sent aloft from launch pad 34.

The third flight, according to Shea, has little to do with the spacecraft development program. It is designed primarily to test the multiple restart capability of the S-IVB second stage. The flight is expected to comprise only two orbit periods.

Shea said *A/S-204,* the first manned flight, will last as long as the spacecraft systems continue to work, but NASA hopes to shoot for a mission of at least 10 and perhaps 14 days.

The spacecraft is now beginning checkout at North American and is scheduled to be delivered to Cape Kennedy about mid-year.

Its launch date will depend upon how many system changes are made because of the results of the first two flights. It is expected, however, that the first three manned missions may be flown either in the third or fourth quarter of this year.

A/S-205 will be the final Block I spacecraft (composed of only the Command and Service Modules) flight and it will be used primarily to verify the results of the first manned flights.

On to Block II—The sixth launch in the series will mark the first use of the Block II spacecraft and is designed to flight-test an unmanned Lunar Excursion Module (LEM).

A/S-207 will then be the first LEM mission—and, it is hoped, the last flight in the series.

If the *Saturn V* is ready in mid-to-late 1967, the remaining *Apollo* manned flights will be launched by the 7.5-million-lb.-thrust booster. If not, NASA is ready to make about two more flights with the *Saturn IB* in order to practice *Apollo* rendezvous procedures.

Whether the *Saturn V* will be ready for an unmanned launch in the first quarter of next year is a moot point at this time. The first S-1C flight stage underwent its final test-firing late last week. A planned 85-sec. firing of its five F-1 engines was scheduled for Feb. 25. It followed a successful 40-sec. firing at the Marshall Space Flight Center's static test stand on Feb. 11.

After last week's test, the huge stage was to be moved to the Quality Test Laboratory for two to three months of refurbishing and checkout. It is expected to be ready for shipment to Cape Kennedy just about on schedule near the middle of the year.

S-II slippage—The same situation, however, does not prevail for the 1-million-lb.-thrust second stage. NASA officials report that the five-J-2-engine-powered stage is three to four months behind schedule.

It is currently undergoing final assembly at the North American Aviation plant at Downey, Calif., and is scheduled to be sent to the Mississippi Test Facility for test firings around mid-year. It will then have to undergo refurbishment and checkout, and it appears doubtful that it can be delivered to Cape Kennedy much before the end of the year.

NASA officials maintain that the slippage in the S-II schedule will not delay the first launch of the booster. The agency's unofficial schedule has the first flight set for December, 1966, but NASA officially sets the date as the first quarter of 1967.

NASA's problems with the S-II are pinpointed by changes in its budgetary plans. Material distributed now indicates that the agency is spending more money in fiscal years 1966 and 1967 on the comparatively small second stage than it is spending on the huge 7.5-million-lb.-thrust first stage.

NASA's Fiscal '66 budget request to Congress originally asked for authority to spend $273.3 million on the first stage and only $227.5 million on the second stage. NASA now estimates, however, that it will spend $255.8 million on the second stage and only $237.5 million on the first stage.

In Fiscal '67, NASA has requested authority to spend $257.7 million on the second stage and only $215.6 on the first stage. ■

Experiments for 1969 Mars Flight To Be Picked by May

by Rex Pay

PASADENA, CALIF.—Experiments for the 1969 *Mariner* Mars mission will be selected by May. It is expected that by mid-summer the spacecraft's system design will be frozen. Most of the hardware will have been designed by the end of the year.

In outlining this schedule, Harris ("Bud") M. Schurmeier, Jet Propulsion Laboratory's project manager for the 1969 mission, told M/R that the time available to prepare the *Mariner* Mars spacecraft will be adequate if an upgraded fly-by mission is selected.

"If you go, though, to an atmospheric probe, it's very tight," he added.

Current studies at JPL are examining alternative missions, including varíous degrees of improvement of the 1964 fly-by mission, up to a mission in which a probe is ejected into the Martian atmosphere.

Money bind—The degree of improvement is primarily limited by resources. Some $130 million has been allotted to exploration of Venus in 1967 and Mars in 1969. Of this, about $30 million has been tentatively set aside for the Venus mission, which involves one spacecraft (M/R, Feb. 14, p. 33).

The remaining $100 million has to pay for two *Atlas-Centaur* launches—two flight spacecraft plus one fully-qualified spare, a proof-test model, and some qualification-type equipment—the same amount of hardware units procured for the 1964 *Mariner* Mars mission.

The 1964 spacecraft weighed 575 lbs. and the mission cost $126 million. In comparison, it is hoped that a spacecraft weighing about 800 lbs. will be flown to Mars in 1969. Hence, the central question in this mission is how to spend less and fly more.

Obviously, costs can be kept down by retaining as many of the *Mariner 4* subsystems as possible. Unfortunately, raising the weight of instruments carried calls for changes in most subsystems.

A letter calling for suggestions for experiments for *Mariner* 1969 went out in January. It gave a tentative estimate of 70 lbs. of instruments, 30 lbs. on the scan platform. This compares with 40 lbs. of instruments on *Mariner 4*, 8 lbs. being on the scan platform.

Changes looming—Checking through the subsystems of *Mariner '69*, Schurmeier suggested that the command system was likely to be the only one that probably will remain the same. The attitude-control system will also remain basically the same, although the size of the gas jets may have to be increased.

The mid-course propulsion system may have to be boosted in performance if the spacecraft weight goes up to 800 lbs. The power system (solar panels and power-conditioning equipment) will have to be modified if the new instruments draw more power.

Changes are likely to be made in the communications subsystem; how much it can be upgraded is currently under consideration. The spacecraft structure may also change, since it depends on the mission. The thermal control subsystem will be of the same type, but the change in instrument payload probably will mean an increased thermal output.

Most detailed work on the atmospheric probe studies is being carried out by NASA-Ames and its contractor, Avco. A non-survivable probe of some 50-100 lbs. that would transmit data on the atmosphere to the fly-by bus for relay back to Earth is envisaged.

"If we did an atmospheric probe we would have to have a relay link through the spacecraft, and this makes this mission quite complicated and costly," said Schurmeier.

Not only does the probe itself have to be developed, but sterilization procedures are required, along with a separation mechanism, and the relay system for telemetry through the main spacecraft. All this new equipment must be flight-qualified, Schurmeier pointed out.

Earth return—Another alternative to the probe and upgraded fly-by missions is the Earth-return mission, where encounter data is stored until the spacecraft returns to the vicinity of Earth. Schurmeier said this is not being considered for the 1969 flight. "It just does not look as if there are funds for that much of an upgraded mission," he said. To make this type of mission worthwhile, the data stored at encounter has to be increased by several orders of magnitude compared with *Mariner 4*, and this does not seem possible with the resources available.

The *Atlas-Centaur* booster can send about twice as much payload to Mars as it is going to be asked to do in 1969. "We have a lot of excess performance, so that in principle we can think of flying high-energy trajectories," said Schurmeier. However, other aspects of the trajectory must be cleared up before any decision of this type can be reached. There may be some problem with the launch azimuth out of Cape Kennedy—during the 1969 opposition the transfer trajectory has a very negative declination.

The change in launch vehicle will mean that a new interface between it and *Mariner* will have to be developed.

Weight considerations—Not all the increase in spacecraft weight may be aimed at increasing scientific payload. Some of the additional weight might be used to make the spacecraft more reliable, or cheaper. *Mariner 4* was very severely weight-constrained, so the designers went to extremely lightweight solar panel structures. JPL is now examining whether it will be cheaper to duplicate these, saving development costs, or produce a new, more robust design, which would have to go through all the qualification procedures again.

It is also possible that some of the increase in weight might be taken up with increases in redundancy. Trade-offs between risk and cost will be carried out in this area.

Another consideration that enters into the design picture is that a "standard" *Mariner* spacecraft is desirable to reduce costs of future missions. JPL studies suggest, in fact, that *Mariner* spacecraft will have wide application through the 1970's and even through 1980.

Schurmeier said that spacecraft design will proceed from some arbitrary guesses based on the initial inputs from experimenters. The various approaches will be evaluated with regard to cost, development risk, and implication for the spacecraft. After final selection of the experiments and mission, the design can be frozen.

Flexible contracting—The role industry will play in this mission is now being examined. It will vary according to the mission and to the number of changes that will be required in the spacecraft. "In general we would like to get them in to participate through the latter part of the system design," said Schurmeier (M/R, Feb. 21, p. 14).

JPL will retain responsibility for system design work. There will not be a prime industrial contractor for the system of the type envisaged for *Voyager*, although JPL may seek support from a contractor for this task. Increased industrial participation will come from contracts for larger subsystems. For example, there might be one contractor for the attitude-control system, whereas on *Mariner 4* a number of different contractors supplied components to JPL. ■

THOSE MAGNIFICENT MEN IN THEIR FLYING MACHINES

"Classic Antoinette" From the 20th Century-Fox motion picture "Those Magnificent Men in their Flying Machines".

...Variable Wing

In 1908 the Antoinette was born of canvas, balsa and just plain gall!
The Antoinette shared honors with Bleriot as the first aircraft to establish the monoplane design. The wings were of trapezium form and, in order to facilitate warping, the rear spars were pivoted to the fuselage. This allowed the wings to rock differentially.

The ghost of Antoinette lives on in the F-111B Navy version of the U. S. Air Force/Navy bi-service fighter now being built at Grumman. The F-111B, with unique variable sweep wing which can be swept back from a 16 degree, to a 72.5 degree sweep, gives the new aircraft the capability to operate from carrier decks, short unimproved landing strips, and also to fly at speeds up to two and one half times the speed of sound. It is the free world's most formidable fighting aircraft.

The designers of the two aircraft shown here had one thing in common . . . an enterprising spirit with no inhibitions to innovation. This spirit permeates Grumman. Engineers and scientists whose outlook includes a generous dash of the same are urged to explore these immediate positions at the company:

Fluid Support Engineers—BSME with a minimum of 2 years experience in one or more of the following areas: Hydraulics, pneumatics, propulsion cryogenics, air-conditioning or vacuum technology.

Structural/Mechanical Design Engineers—B.S. in M.E., CE, or equivalent for design & layout of mechanical aircraft & spacecrafts support equipment to MIL-specs requirements.

Liaison Engineers—BS or equivalent with experience in aircraft design & a good practical knowledge of production fabrication methods & drafting procedures. Must have ability to analyze production difficulties & develop & carry through necessary engineering revisions. Both Sr. & Jr. level positions available in all aerospace systems.

Materials Review Engineer—BS in AE, ME or CE with a minimum of 2 years experience in stress analysis of aircraft structures. Will perform structural and functional analysis as necessary to develop and prepare disposition of discrepant and damaged aerospace material and structures.

Structural Test Engineers—B.S. or equivalent in A.E., C.E. or M.E., & a minimum of 1 years experience in structural testing or 3 years of industrial experience, to work on advanced aircraft & spacecraft vehicle programs.

Aero-Test Design Engineers—B.E. in ME or AE. Familiar with drafting, stress analysis & fabrication techniques. Will be responsible for design of wind tunnel models & experimental laboratory equipment. Will consider tech school grad with appropriate experience.

Senior Thermodynamicists—Advanced degree with minimum of 5 years experience performing heat transfer analysis. Specific opportunities in aerodynamic and re-entry heating, structural temperature determination and heat transfer phenomena in propulsion systems.

Heat Transfer Engineers—BSME to work on thermal design of space electronic systems. Must be able to perform detailed analyses of electronic equipment cooling requirements and direct necessary thermal test programs.

Additional opportunities on following page

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(Continued from previous page)

Thermal Control Engineers—Engineer with experience in handling space vehicle temperature control system analysis. Should have background in radiative heat exchange and thermal coatings as applied to passive and active temperature control systems.

Propulsion Technology Engineers—B.S. or M.S. & a minimum of 3 years experience in one or more of the following areas: Fluid Dynamics of air-breathing or rocket propulsion systems; air induction systems & internal aero-dynamics; exhaust systems, nozzles, combustion & propellant analysis; advanced propulsion devices. Analytical &/or experimental background is helpful at both Jr. & Sr. levels.

Rocket Propulsion Design Engineers—B.S. in Engineering with experience in one or more of the following areas: Design of liquid rocket motors & related systems; development & design of storable bipropellant rocket systems; gas pressurization & cryogenically fueled power supply systems.

Reaction Control Systems Engineers—B.S. with a minimum of 3 years analysis & test experience in small pulsed rocket engines. Responsibilities include the analysis of steady-state & transient flow & pressurization systems. Programming background is helpful. Both Sr. & Jr. positions are available.

Air-Breathing Propulsion Engineers—B.S. or M.S. with 3 or more years applicable experience in aircraft or aircraft engines. Knowledge of compressible fluid flow, engine cycle analysis, ejector design, or induction system optimization is required. Experience with trade-of studies including cost, risk, schedule as well as weight, mission, fuel, volume & complexity is desirable. Opportunity available for growth into position of propulsion project leader on aircraft projects & advanced development programs.

Loads & Criteria Engineers—BS or MS with a minimum of 5 years experience in the estimation of air loads on aerospace vehicles. Specific capability to develop loads distributions on fuselages, span & chord loadings on wing & tail surfaces, & to estimate balance loads is essential. Selection of critical design conditions requires familiarity with applicable specifications.

Experimental Dynamics Engineers—To perform tests & analyses in the fields of dynamics, with special emphasis on vibration, shock & flutter. Work includes: determination of resonant vibrational characteristics, analysis & resolution of in-flight shock & vibration problems; definition of environmental vibration & shock levels for reliability & qualification testing; planning, execution & data analysis of dynamic model test programs to investigate such areas as flutter, buzz, buffet & impact landing & catapult loads. Knowledge of instrumentation & vibration excitation systems is desirable. Engineering degree preferred.

Environmental Vibration Engineers—B.S. degree with a minimum of 5 years related experience in the prediction of vibration & shock environments for spacecraft, translation into specifications & verification of design adequacy by analytical & experimental means. Familiarity with techniques & equipment for sinusoidal & random vibration test & analysis is required, as is experience in specification interpretation. Moderate travel for vendor & customer contact necessary.

Weight Control Engineers—To originate and contribute to, the development of practical minimum weight design and conduct trade-off studies for vehicle weight optimization. Will also carry out weight control during design and production of deep submersibles; aerospace structures & systems. BS & 5 years aerospace experience within your specialty & general engineering competence are required.

Structural Mechanics Engineers—Engineers to establish the technology needed by the structural Analysis & Loads & Dynamics Sections in the design of aircraft, missiles, spacecraft & other vehicles. MS or PhD in AE, CE, ME or Applied Mechanics or equivalent exp & education is prerequisite. Both Junior, Senior positions avail.

Thermal-Structural Engineers—M.S. in Engineering with specialization in heat-transfer or equivalent experience. Will perform structural temperature calculations and participate in the thermal-structural design of aerospace vehicles and their heat-protection systems.

Structures Engineers—Structures Engineers to participate in the design, & conduct the necessary structural analysis to substantiate the design of deep submersibles, aerospace vehicles, & ground support equipment. A working knowledge of the basic methods of stress analysis including the fields of plates & shells, redundant structures & fatigue strength analysis is desired. B.S. or M.S. in AE, CE, ME, or applied mechanics or equivalent is required. Both Senior & junior level positions available. AEROSPACE EXP. IS DESIRABLE, BUT NOT MANDATORY.

Structural Engineers—to work "On-the-Board" as Designers (not Draftsmen). Must have BS in AE, CE, ME or the equivalent technical training with a minimum of 3 years experience & capable of doing own detail stress analysis on deep submersibles & advanced aerospace vehicles.

Crew Station Designers—B.S. in Engineering for assignment in development & design of cockpit & crew station sub-systems. Positions also available for Engineers having education & experience related to equipment arrangement & support provisions.

Use the attached inquiry form to arrange a mutually convenient interview.

Ideal for mounting, an 8 x 10 color photograph of the pioneer aeroplane on previous page is available free, at no obligation, to qualified engineers and scientists (who identify themselves as such). Write address as shown in inquiry form.

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For your convenience and to facilitate your inquiry, please use this form. It will enable the professional staff at Grumman Aircraft to evaluate your background and experience and arrange for a mutually convenient personal interview. All inquiries will be held in strictest confidence. Enclose in an envelope and send to Mr. P. M. Van Putten, Director of Employment, Dept. GR 86, Grumman Aircraft Engineering Corp., Bethpage, L.I., N.Y.

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Major Specialty______Yrs.______Other Specialty______Yrs.______

Applying for position(in)(of)________

Circle No. 7 on Subscriber Service Card

Technical Countdown

ASTRONAUTICS

Martian Probe Studies Enlarged at Avco

Data returned by the *Mariner* flyby of Mars spawned additional work on two contracts completed by Avco Research and Advanced Development Div. Totalling about $400,000, the NASA contracts involve extending recently completed work on a small probe vehicle designed for the Ames Research Center and the design of a large Martian-atmospheric probe for the Langley Research Center. These add-on programs bring to nine the total of *Voyager*-related contracts now under funding at Avco/RAD. The Ames probe will also be modified for use within the atmosphere of Venus, increasing the operational use of the basic vehicle design.

LIFE SUPPORT

Mix n' Match Space Food Developed

Further effort on providing acceptable freeze-dried foods for space use is being carried on by the U.S. Army Natick Laboratories for NASA's Office of Biotechnology and Human Research. Aim of the program is to develop 30 different meal items which will store in a volume of 7,000 cm^3 and provide 18,000 calories. Serving form will be in bars and sheets, and NASA hopes that by making such combinations as bars of meat with sheets of gravy or potatoes, such menus as creamed beef and hashes can be provided. Eventual objective is to reduce volume to one-third that required by the present state of the art.

Army Readying for Spacesuit Tests

Construction has been initiated on a test chamber designed specifically for NASA's program on passive spacesuit cooling techniques being carried out by U.S. Army Natick Laboratories. Analytical investigations have been completed on two sweat-removal concepts to be tested for feasibility with the eventual hope of selection, design and testing in integrated form in a complete suit. NASA's objective is to eliminate gas-cooling systems and associated hardware, and increase mobility by improved pressurization concepts.

SPACE MEDICINE

SAM Increasing Radiation Equipment

The Air Force's School of Aerospace Medicine is planning to add a whole-body counter and scanning equipment to be used with its work on proton radiation effects. Bids are now being called for a sodium-iodide crystal scanner, and there are plans for a liquid scintillation counter, capable of use with both humans and lower animals. SAM's new Radiation Science Laboratory is almost completed, and will have a Maxitron 300 X-ray machine, a neutron generator and an electron linear accelerator operating by mid-year.

UVA Reports on Radiation Studies

Aspects of research on the radiations of space are being carried out by the Virginia Medical College for NASA. The effects of space-particulate radiation and soft X-rays on mammalian eyes are being determined by exposing rabbits to protons from the synchrocyclotron and Bremsstrahlung from targets irradiated by electron accelerator. The rabbits are then checked for hardening of the lens, transmission of light, and formation of cataracts. The effort also includes in-vivo and in-vitro experiments at the cellular level to check for chromosomal aberrations in the lens epithelium.

Cancer Develops from Radiation Study

Yet another phase of radiation is under investigation for NASA by the University of Michigan, which has been simulating space radiations to see whether carcinogenesis will result from such exposures. Rats are being exposed to the cosmatron beam at Brookhaven National Laboratory providing radiations in excess of 2 Bev protons. In one test, in which 32 rats were exposed to 4×10^{10} protons equivalent to 400 R of cobalt 60, six were found to develop tumors. Two of these were malignant.

PROPULSION

ARC Frangible Rocket Tested

An automatic fragmentation system set to destroy launch vehicles in the upper atmosphere some 20 secs. after payload deployment passed its initial flight tests at the Naval Missile Test Center, Point Mugu, Calif. Designed and built by Atlantic Research Corp., the new 70-lb., solid-fueled sounding rocket uses a filament-wound, glass-reinforced, plastic motor case and hollow magnesium fins. These components are totally destroyed after payload separation. A back-up fragmentation system is activated by a barometric sensor above 60,000 ft. should the primary device fail. The concept permits the use of such weather rockets in populated areas. The design is two pounds heavier than ARC's standard *Arcas* sounding rocket—2,500 of which were used throughout the world last year.

Huge New Autoclave Installed

A 12,000-cu.-ft. autoclave is being installed at the Plastics Div. of Heath Tecna Corp., Kent, Wash. The 15.5 x 32 ft. unit is expected to be used for curing reinforced plastic and honeycomb components for aerospace, aircraft and marine programs—including sections of the Supersonic Transport. Two radiant-tube gas heaters using 3,000 cu. ft. of gas per hour will heat the $200,000 processing unit. The autoclave is engineered to operate at 100 psi using inert pressurizing gas and at 450°F. The air recirculation rate is 60,000 cu. ft./min. At full-pressure operation there will be an effective force of 3,000,000 lbs. on the door.

Electrical Properties of Plastics Tabulated

Data compiled from 1,600 technical papers presented at 49 conferences and meetings between March, 1960, and March, 1965, on the electrical properties of plastic materials are now available in a Plastec Report. Several indices included facilitate data retrieval. Those interested may obtain copies of the document by writing the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151, and requesting Plastec Report 23 entitled "Electrical Properties of Plastic Materials" ($5.00). The report originated at the Plastics Technical Evaluation Center, Picatinny Arsenal, N.J.

Apollo Land Recovery Tests Continue

MSC develops system for Apollo-weight spacecraft; maximum load capability of 14,000 lbs. foreseen; work called 'strictly R&D'

by Jinx Mercer

HOUSTON—Tests are under way to develop an Earth-landing system for spacecraft of the *Apollo* weight class.

In a recent drop test, a controllable parachute lowered a 2½-ton "spacecraft" from 15,000 ft., verifying the 49-ft.-dia. cloverleaf configuration sized for a 5,000-lb. weight. In follow-on tests, the size of the parachute will gradually increase until a load-carrying capability of 12,000 to 14,000 lbs. is achieved.

The fully developed system is not aimed at *Apollo,* spokesmen at the Manned Spacecraft Center emphasize. Purpose is to improve the state of the art in recovering spacecraft on land and to provide an option in landing modes for spacecraft.

MSC engineers developed and successfully demonstrated an Earth-landing system for spacecraft of the *Gemini* weight class. This system, which "represents the current state of the art," consists of a controllable parachute, impact attenuation rockets and skid-type landing gear left over from the paraglider—the original land recovery system planned for *Gemini* spacecraft.

Suggested for Gemini—During its development period, MSC spokesmen also reiterated that the controllable parachute/landing rocket system was not aimed at any particular vehicle. Program planners here, however, recommended that the Earth-landing system be incorporated into one of the *Gemini* spacecraft, preferably the final mission vehicle, *Gemini-12.* They were turned down by NASA Headquarters, which felt that inclusion of an Earth-landing capability at such a late date would disrupt program scheduling and increase program costs.

More than $20 million was spent on the paraglider Earth-landing concept for *Gemini.* Development problems of the inflatable, delta-wing device threatened to hold up the *Gemini* program until it was decided to continue bringing spacecraft down by conventional parachute to a water landing.

NASA continued the development of a land recovery system but chose an alternate method—essentially a compromise between the steerable gliding capability of the paraglider and the conventional parachute descent. The system was built around Pioneer Parachute Co.'s "parasail" and costs more than $1 million to develop.

After a capability demonstration, the landing system was detailed in a technical report and shelved. A complimentary copy was forwarded to the Air Force, whose *Manned Orbiting Laboratory (MOL)* program will also utilize *Gemini*-type hardware.

R&D only—In the meantime, MSC engineers moved on to the intermediate step in development of a large, controllable parachute in the 12,000- to 14,000-lb. weight-carrying class. John W. Kiker, head of the landing technology branch, said the work is "strictly R&D."

He added that work was also under way on a conventional parachute in the 20,000-lb. weight-carrying class. This, too, was not aimed at any particular vehicle.

Thiokol Evaluates Solids for ICBM Use

Techniques to improve performance of volume-constrained ICBM propulsion systems checked out successfully in test-firing of a 120-in.-dia. solid rocket at Thiokol's Wasatch Div. Motor used a 25-in. throat submerged, omni-axis gimbal nozzle in the 70-sec. demonstration firing which reached temperatures exceeding 6,000°F. Program is being funded by the Air Force Ballistic Systems Div.

Personally, Kiker said he feels that at sometime in the future, a land recovery should be made "if for no other reason than those that compel people to climb mountains; it would be done to advance the technology."

Although he cannot envision real economic savings by going to land recovery now, he foresees "large savings" in refurbishing logistics or resupply vehicles brought back to Earth on land instead of water.

The *Apollo* weight class system is scheduled for completion in May, 1968, following approximately 13 months of full-scale tests at either El Centro or Edwards AFB, Calif. It will consist of a controllable parachute, landing attenuation rockets and a mechanical impact system. Kiker's group is defining requirements for such a system and hopes to begin development of full-scale components by the end of this year.

Alternatives—Two parachutes are being evaluated—a cloverleaf shape designed by the Ventura Div. of Northrop Corp. and an advanced version of the parasail developed by Pioneer.

Half-scale designs of each parachute are now being evaluated in helicopter drop tests near MSC with a 350-lb. weight. Kirby Hinson and Lee Norman, in charge of the descent system evaluation, explained that the cloverleaf has a significant lift-to-drag ratio (L/D) and can be modulated to lower values. It has already demonstrated an L/D of 1.8—a forward speed 80% higher than anything achieved in steerable parachutes. "This forward speed also can be modulated without affecting the rate of descent," Norman added.

The parasail has a fixed L/D of one. Some engineers feel that it may not be desirable to force the pilot to modulate the L/D in the final 300 to 400 ft. of descent, and that a fixed L/D might prove to be adequate, Hinson said. "Right at the moment, the parasail has a significant weight advantage."

A decision on a parachute for the next generation spacecraft Earth-landing system is expected about the middle of this year, they said.

The full-scale system for *Apollo* weight class spacecraft will have a controllable parachute approximately 90 ft. in diameter with an L/D of 1.5 to 2.

The engineering group is also looking into landing dynamics of a variety of rockets and mechanical impact systems. Optimum combination of parachute and landing attenuation system for the 12,000- to 14,000-lb. vehicle will be firmed up by December, 1966.

By April, 1968, "we hope to have the entire system, including the backup or crew escape system, demonstrated under design conditions," Norman said. This is where their work will officially end. ■

French Centaure To Carry German Particle Collector

Friedrichshafen, Germany—A micrometeorite collector is being developed by the research and development department of Dornier System GmbH, for launching with the French Sud Aviation *Centaure* sounding rocket next year.

The probe will collect micrometeorites above altitudes of 80 km and return the samples to Earth uninfluenced by the atmosphere.

The Dornier probe will determine the vertical and horizontal components of the meteorite flux, and the altitude dependency of the meteorite density.

When the ascending rocket reaches the designated altitude, the shell of the probe will be shifted forward, exposing the vertical collector plates. The horizontal collectors will be deployed by a combination of spring release and centrifugal force supplied by spinning the payload.

The entire unit retracts all elements and reseals itself to prevent atmospheric contamination of the collected samples during its return to Earth. The probe is being built by Dornier under contract to the Max Planck Institute of Germany.

Probe design—A multiple-seal arrangement ensures that all particles on the collector plates will be free of contamination by terrestrial dust.

The entire inner space is sealed by a gasket between the rim of the cover shell and the base flange. A second cylinder seals the horizontal collector-plane system so that it can be installed and removed in the sealed state.

This cylinder is attached to the outer shell in a disconnectable fashion. All the horizontal collector plates are individually sealed by O-rings at the upper edge of the slides.

Operation—The outer cylinder slides forward through a pneumatic system in operation. Each slide is actuated by its own piston-cylinder system and the piston rod is locked in the retracted position by a bolt. Retraction of a pin releases the latching system.

In the locked position, a helical spring presses down on the piston head, and in releasing the lock, lets the spring push the piston some 10 cm out of its position. The centrifugal force now acting on the probe pulls the slide out to the stop.

A compressed-nitrogen gas system retracts the slides prior to probe descent. The Conax valves are actuated pyrotechnically by means of a timer in the pre-selected sequence.

Collector system—The eight vertical collector plates are exposed after shifting forward of the shell. Contamination is avoided by fixing the collector plates to the supporting cylinder by screws carried through holes in the cylinder and turned into tapped, blind holes in the trays.

The horizontal collector plates are mounted on movable slides. There are six such units and two of these are designed to retract slowly—giving the meteorite density dependence on altitude.

The slide housing has flanges grooved and provided with O-rings. Each pair of slides moving in opposite directions is connected so that the accidental stop of one slide automatically stops the opposite slide at the same distance from the center of the payload. This prevents any imbalance of the probe during slide deployment. The opposite slide pairs are mechanically synchronized.

The vertical contact pressure of the slides against their seals is caused by a system of knee levers actuated as soon as the horizontal motion ceases. Opening and closing times are about three seconds.

Each cycle of the slides and the shell is controlled by mechanical contacts. Periodically marked paper strips coated with aluminum are fixed to the undersides of the extending slides as an aid in calculating the altitude dependency of the slide's position in combination with trajectory data.

A pressure sensor will monitor the environments of the vertical collector plates and the shell spacing. ■

Hospital To Benefit from Space Work

Spacelabs, Inc., will deliver to civilian institution first solid-state patient-monitoring system available to doctors

by Heather M. David

THE SMALL ELECTRONICS company which copped the *Gemini* and *Apollo* bioinstrumentation contracts out from under the noses of the established medical instrumentation companies is now putting this experience into the hospital intensive-care monitoring field, as well as into further space-related work.

Spacelabs, Inc., Van Nuys, Calif., is scheduled to deliver next month the first all-solid-state patient-monitoring system available to the medical profession. The unit is being installed in Valley Presbyterian Hospital in Van Nuys and will display electrocardiograms of four cardiac patients on a 17-in. oscilloscope.

The unit is designed to monitor bedfast patients with hardware equipment, but can be changed to a telemetry system as patients are given walking privileges. In this case, the Spacelabs signal conditioner is worn in the hospital gown.

Working on the philosophy that each hospital should be able to design its own equipment, Spacelabs has constructed the system in such a way that additional patients can be accommodated, as well as almost any combination of parameters on each patient.

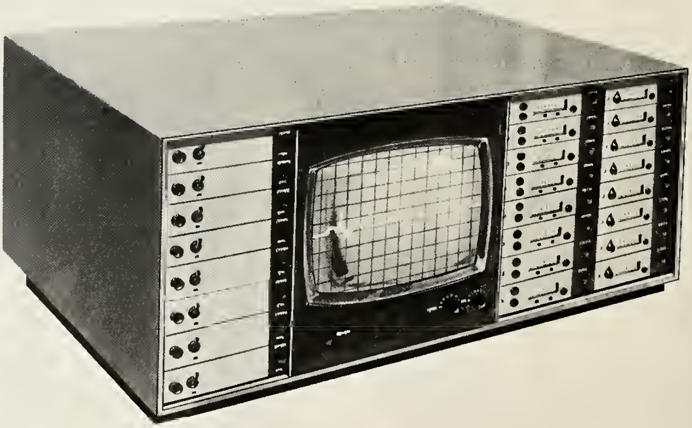
Other parameters which could be measured include electroencephalogram, arterial pressure, venous pressure and temperature. Temperature can be measured orally or underarm. Spacelabs engineers also are looking at the possibility of sensing the temperature of the tympanic membrane through use of a thermistor bead coated with silastic material inserted in the ear.

Some of the company's space-work fallout which it feels makes its equipment superior for hospital use is the all-solid-state circuitry, extremely high input impedances, and low noise levels. High reliability is reportedly achieved through use of circuits designed for normal use at only 30% of their capacity and welded module construction.

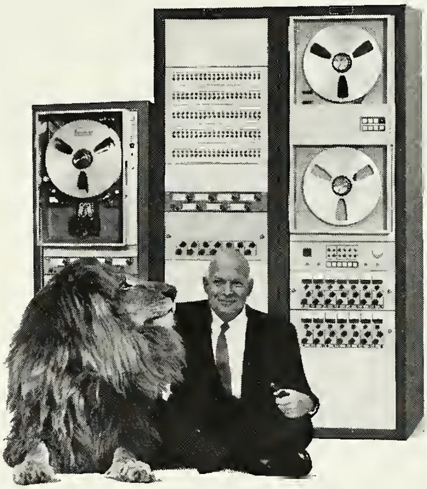
LEM simulator unit—Another project under way at Spacelabs is the biomedical monitoring console built for

ABOVE: Printed circuit board assembly line at Spacelabs, Inc., Van Nuys, Calif.

BELOW: Biomedical instrumentation technology developed by Spacelabs for space has been applied to civilian use, to aid heart patients, with Intensive-Care Patient Monitoring System, which monitors eight electrocardiograms simultaneously.



Mincom recorders and the Apollo Program



Instrumentation recorders used for telemetry tracking in the Apollo program will be supplied by Revere-Mincom, under a series of contracts awarded in 1965.

Fifty wideband and thirteen intermediate-range recorders to NASA-Goddard SFC for a global network of ground-based and shipboard tracking stations. Seventeen Mincom recorders to The Bendix Corporation for airborne telemetry in ARIA (Apollo Range Instrumentation Aircraft).

With existing installations, these contracts make Revere-Mincom one of NASA's largest suppliers of instrumentation tape recorders.

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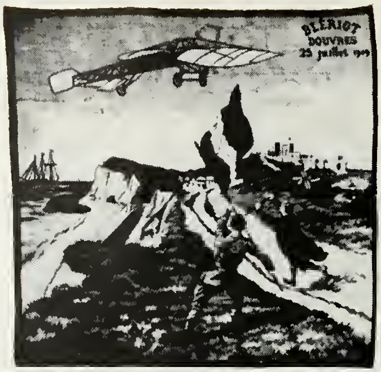

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Quality-control consoles at Spacelabs test intensive-care unit modules. System may be expanded to monitor temperature, respiration and other parameters.

Grumman Aircraft Engineering Corp. as part of the Lunar Excursion Module internal environment simulator.

This unit displays the heart rates, respiration rates and skin temperatures of the two astronauts who may be undergoing various tests in spacesuits in the simulated spacecraft atmosphere. These are displayed both digitally and by meter and on an oscilloscope.

Other measurements provided by the unit include suit pressure and oxygen and carbon dioxide concentration. These are displayed on meters with adjustable high- and low-limit alarms. Both audible and visual alarms signal that an acceptable limit is being exceeded.

Heart sounds also are presented on an oscilloscope, as well as being recorded permanently. Almost all physiological parameters, in fact, are recorded on both a high-speed dual channel and a slow-speed multipoint recorder.

Closed-circuit television and continuous intercom also are provided on the console.

Spacelabs history—The Spacelabs story is somewhat the Horatio Alger history in the space field. The company was started in 1959 by present Chairman Ben L. Ettelson and President James A. Reeves. From this beginning, the company has grown to 113 employees and annual sales of from $2 to $3 million.

One of the firm's early projects was implantation of bioinstrumentation devices in monkeys for use in suborbital spaceflight for the Air Force.

This led to further Air Force contracts such as development of a family of standardized telemetry modules for the School of Aerospace Medicine. This included sensors, amplifiers, voltage-controlled oscillators, transmitters, discriminators and receivers in a system called the Model 130 BIOTEL, designed for use in a multitude of research situations.

Other projects along the same lines included the Viability Data Acquisition and Display System (VIADAT), designed to acquire physiological data from humans or other primates in long-duration tests in an environmental chamber. This unit senses respiration, pressure by cuff, electrocardiogram, peripheral pulse by photoelectric means, phonocardiogram, skin resistance, body temperature and partial pressure of oxygen and carbon dioxide. This unit also was developed for the Air Force Aerospace Medical Div.

The company is also participating in a NASA project at the Flight Research Center to advance the state of the art in biomedical monitoring in flight. In addition to instrumentation development, Spacelabs has an on-site team performing test and evaluation, coordination of technical requirement and other technical problems.

Under contract to the Air Force Avionics Laboratory, Spacelabs developed a myoelectric servo-boost brace. This unit translated the electric signals produced by the human operator's muscles into signals which powered a brace capable of restoring arm movement to the subject when he was restrained by a high-g field.

Another unique project originated by Spacelabs was development of an ear microphone—a unit which was tucked in the subject's ear to pick up and transmit voice signals.

The company has also entered the space sanitation and hygiene field with development of a system to maintain sanitary conditions within an aerospace vehicle during long-duration missions. This consisted of an equipped hygiene station with connections for a bathsuit in which astronauts could fully bathe.

Among the largest contracts, however, have been the bioinstrumentation for *Apollo* and for *Gemini*. Spacelabs' *Gemini* equipment has a 100% reliability record thus far.

The system being delivered to the Valley Presbyterian Hospital is, however, the company's first production item. ■

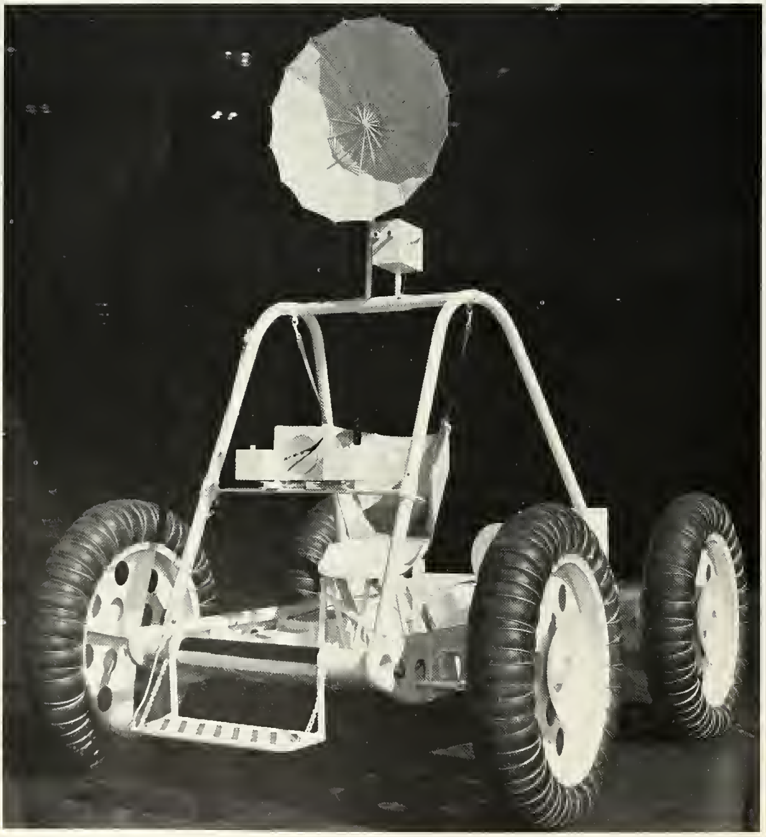
Federal Report Pinpoints Problems

Joint Government committee document cites temperature, strength, weight and degradation difficulties; contains recommendations

by John F. Judge

A REVIEW OF major materials problems areas important to the Federal Government has pinpointed high-temperature materials, high-strength, lightweight materials and the degradation of materials in use as the most crucial.

The analysis was conducted by the Coordinating Committee on Materials Research and Development consisting of members from those Federal agencies with a direct interest in materials research.



Brown Engineering Shows Lunar Vehicle Model

Brown Engineering Co. has proposed this vehicle to NASA as its entry in the local scientific survey module (LSSM) competition. The space agency wants a lunar "car" in which astronauts can make short trips for exploration, survey and data acquisition. The Brown vehicle would be driven by fuel cell- or battery-powered motors.

The committee limited its attention to subjects of importance to the Government. It did not consider problems which may be of national importance but not so recognized by any of the agencies as being of major concern to them.

The report is not considered comprehensive since the recommendations call for special emphasis on certain problems of common interest to two or more agencies; problems of importance to a single Government agency were not included.

Study guidelines—Three general questions were used as guides:

—What are the areas of materials research in which great progress might now be possible because new techniques and concepts coincide with a field ripe for new developments?

—What are the major Federal problems?

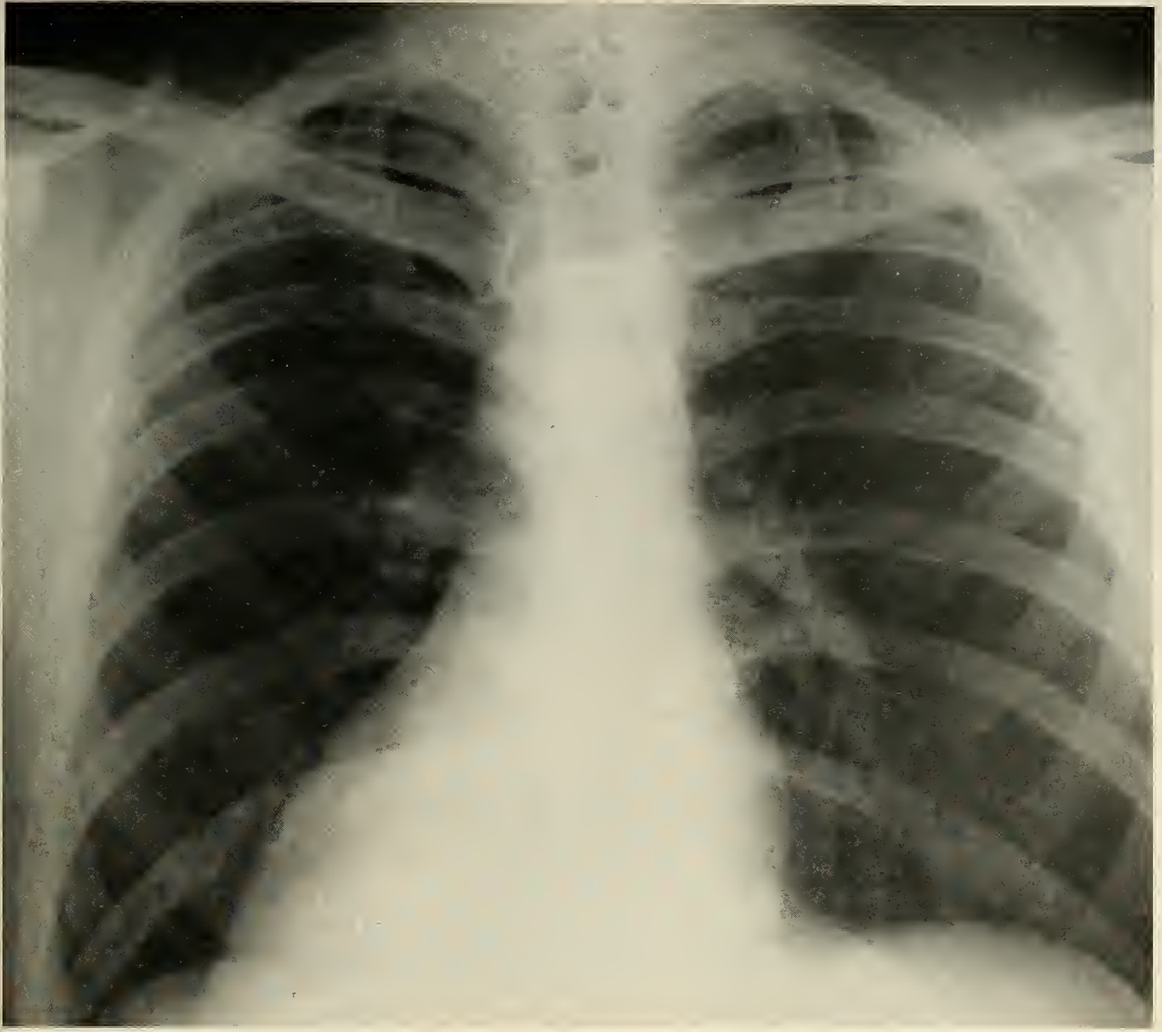
—What are the techniques or facilities, experimental or theoretical, that are holding back materials research on important lines?

In the high-temperature materials area, the most pressing need is for structural improvements. Retention of strengths to temperatures above 1,000° C, together with resistance to degradation by oxidation or other atmospheric attack, by evaporation in vacuum or by irradiation are the qualities most needed.

The committee report notes that this requirement has led to a number of approaches, the dominant ones being the use of composites, refractor metals and ceramics.

The second major problem is development of materials with high strength and low weight, coupled with impact strength, toughness and resistance to atmospheric attack, and capable of being fabricated and joined conveniently and cheaply. Elevated temperature operation is also a consideration.

The complex problem of materials degradation is illustrated by the economic loss involved—some 25% of the U.S. annual steel output goes to replace



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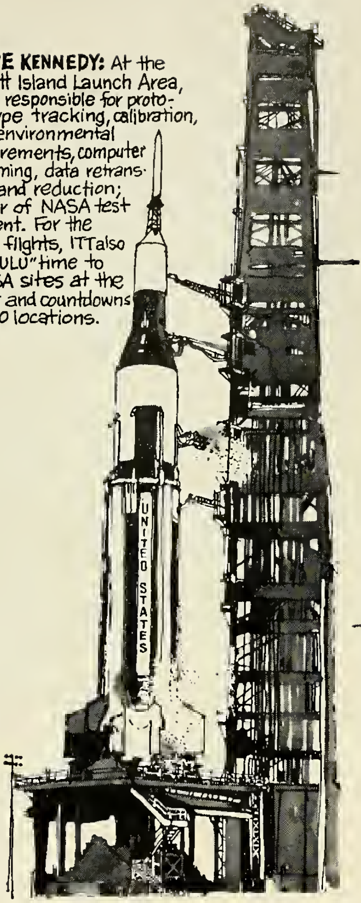
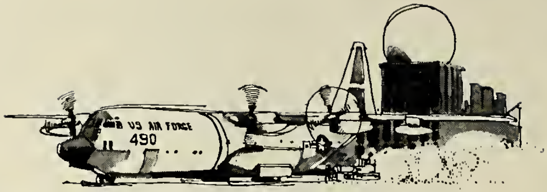
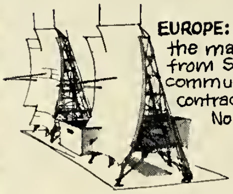


CAPE KENNEDY: At the Merritt Island Launch Area, ITT is responsible for prototype tracking, calibration, launch environmental measurements, computer programming, data retransmission and reduction; and repair of NASA test equipment. For the Gemini flights, ITT also relays "ZULU" time to 150 NASA sites at the Center and countdowns to 80 locations.

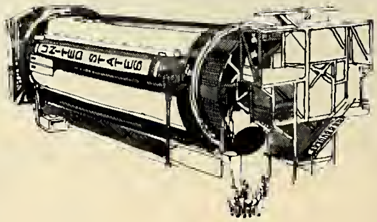


DEW LINE: ITT operates, maintains and supplies the strategic Distant Early Warning (DEW) Line across Alaska, Canada and Greenland. The same responsibility is true for DEW EAST, DEW DROP and NARS.

WESTERN TEST RANGE: Since 1959, ITT has operated the vast ground support equipment needed at Vandenberg AFB, Pillar Point, and aboard 5 range ships for the tracking and monitoring of spacecraft and missiles.



EUROPE: ITT system engineers implemented Project 486L, the massive Air Force communications system extending from Spain to Turkey; installed the U.S. Army's largest communications system (ET-A); and served as prime contractor for the ACE HIGH system stretching from Norway to Turkey.



HUNTSVILLE: At the Marshall Space Flight Center, ITT engineers perform vehicle systems checkout services on the Saturn rockets which will one day carry men to the Moon.

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corroded equipment and products.

General obstacles and routes of opportunity are listed in the 13 recommendations. In evolving these recommendations, the committee assigned them equal importance.

The CCMRD reports directly to the Federal Council For Science and Technology, Donald F. Hornig, chairman. The committee itself is chaired by D. K. Stevens of the Atomic Energy Commission and I. C. Schoonover, National Bureau of Standards, vice chairmen.

Members include G. C. Deutsch, NASA; R. W. Johnston and H. W. Etzel, National Science Foundation; E. T. Hayes, Director of Defense Research and Engineering; J. B. Rosenbaum, Bureau of Mines; and R. M. Thomson, Advanced Research Projects Agency.

Recommendations—The specific recmendations of the committee include:

1) Greater emphasis on the basic study of the mechanical properties, structure, and processes that produce and affect the microstructure of practical, complex materials;

2) Attention to ceramic processing from both the R&D standpoints and favorable consideration given to the now-developing interdepartmental ceramics processing program;

3) Organization of a systematic attack on the problems of deliberate design for use of brittle and anisotropic materials in load-bearing appliciations;

4) Increased effort in new and improved methods of characterizing materials of controlled composition and perfection—including ultra-pure and ultra-perfect crystals and those with deliberately added impurities;

5) Fostered sharing of research materials among labs in a coordinated manner so that data on the properties of a specimen can be accumulated and added to the characterization of the specimen;

6) Continued work on high-temperature properties of materials—particularly development of accurate methods of measurement and collection and dissemination of critically evaluated data on the properties of well-characterized materials at high temperatures;

7) Increased effort to introduce basic, interdisciplinary concepts into corrosion research and on the basic studies of surfaces—their structures and reactions;

8) Increased effort on basic, scientific studies of more complex, less well-understood systems, and on the effects of the more complex radiations found in actual use, in addition to the basic work on radiation damage with model materials and simple radiations;

9) Consideration of the problem of ensuring that the best available understanding of the materials behavior be put to use in all phases of their processing, fabrication and application;

10) Considerable support in basic studies of the nature and properties of the superconducting state;

11) Increased attention to a.) improving the technology of static pressure production and measurement so that accurate measurements of the physical properties of materials may be made under conditions of uniform, homogeneous, accurately-known pressures and temperatures; and b.) studying the behavior of materials under dynamic, non-homogeneous pressures;

12) More emphasis on development and use of new spectroscopic sources in studying properties of materials;

13) Greater attention to the study of the behavior of materials under conditions of transit and non-linear response to changes in external conditions.

The report, "Federal Materials Research Program—Opportunities, Roadblocks and Problems," (TID-22424) may be purchased from the Clearinghouse for Federal Scientific and Technical Information, Dept. of Commerce, Springfield, Va. 22151, at $2.00 per copy. ■

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Apollo PCM Subsystems Come of Age

Block IB model due for fourth flight test on Saturn IB/Apollo last week; redesigned version completes acceptance test series

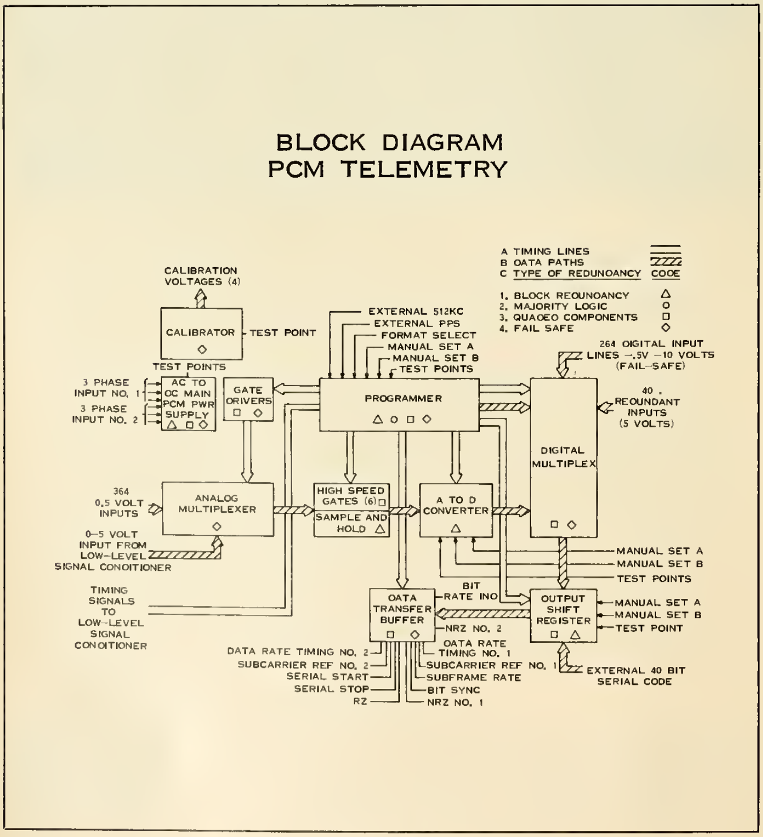
FIRST ACCEPTANCE tests on the redesigned version of the Pulse-Code Modulation (PCM) telemetry subsystem for the *Apollo* program were completed by Radiation, Inc., engineers last week at Melbourne, Fla.

In addition, the fourth in a series of 15 Block IB PCM subsystems was scheduled to fly on the *Saturn IB/Apollo 009* test last week—designed to provide ground stations with telemetered data on *Saturn* vehicle aerodynamics.

Both models of the *Apollo* PCM telemetry were built by Radiation, but their designs are based on differing reliability and environmental specifications—and these differences reflect a significant change in some basic concepts of the U.S. manned spaceflight program.

Three additional *Saturn IB/Apollo* flights are tentatively scheduled for launch later this year, also from Cape Kennedy's Launch Complex 34. In the latest planned flight test, *Apollo 009* consisted of the Command and Service Modules linked in tandem. The Lunar Excursion Module (LEM), with its separate PCM telemetry, will get its first space workout in a later mission.

Block variations—Engineers at Radiation's Melbourne facilities are analyzing the results of the first acceptance tests of the redesigned PCM telemetry subsystem—called Block II. This unit and the earlier Block I versions differ primarily in their fabrication; their electronics are similar.


BLOCK DIAGRAM
PCM TELEMETRY

A TIMING LINES
B DATA PATHS
C TYPE OF REDUNDANCY
CODE
1. BLOCK REDUNDANCY △
2. MAJORITY LOGIC ○
3. QUADDED COMPONENTS □
4. FAIL SAFE ◇
CALIBRATION VOLTAGES (4)
CALIBRATOR
TEST POINT
TEST POINTS
3 PHASE INPUT NO. 1
3 PHASE INPUT NO. 2
AC TO DC MAIN PCM PWR SUPPLY
GATE DRIVERS
EXTERNAL 512KC
EXTERNAL PPS
FORMAT SELECT
MANUAL SET A
MANUAL SET B
TEST POINTS
PROGRAMMER
264 DIGITAL INPUT LINES −.5V −10 VOLTS (FAIL-SAFE)
40 REDUNDANT INPUTS (5 VOLTS)
DIGITAL MULTIPLEX
364 0.5 VOLT INPUTS
ANALOG MULTIPLEXER
HIGH SPEED GATES (6)
SAMPLE AND HOLD
A TO D CONVERTER
0–5 VOLT INPUT FROM LOW-LEVEL SIGNAL CONDITIONER
MANUAL SET A
MANUAL SET B
TEST POINTS
TIMING SIGNALS TO LOW-LEVEL SIGNAL CONDITIONER
BIT RATE IND
DATA TRANSFER BUFFER
NRZ NO. 2
OUTPUT SHIFT REGISTER
MANUAL SET A
MANUAL SET B
TEST POINT
DATA RATE TIMING NO. 2
SUBCARRIER REF NO. 2
SERIAL START
SERIAL STOP
RZ
DATA RATE TIMING NO. 1
SUBCARRIER REF NO. 1
SUBFRAME RATE
BIT SYNC
NRZ NO. 1
EXTERNAL 40 BIT SERIAL CODE

Block I originally was built on modular lines to meet NASA's requirements for self-maintenance. If a particular circuit failed during the mission, the astronaut could remove the defective module and replace it with a spare. In Block II, internal redundancy in a hermetically-sealed package eliminates manual flight maintenance, freeing the astronauts for other duties.

Sam Hersperger, program manager, and Carter Caudill, Jr., project engineer, both of Radiation, Inc., discussed the evolution of *Apollo* PCM telemetry in an interview with MISSILES AND ROCKETS.

They noted that subcontracts received so far by Radiation from Collins Radio Co., Cedar Rapids, Iowa, for the PCM equipment total about $15 million, divided about equally between work on Block I and Block II versions. Collins is prime contractor on *Apollo* data and communications subsystems.

Under the original contract of Dec. 7, 1962, Caudill said, no provision was made for any circuit or block redundancy; in fact, the in-flight maintenance concept was specified for all data and communications subsystems in the Command Module.

Evolution—Hersperger said that during prequalification tests in late 1963, it was discovered that the PCM equipment and other Command Module subsystems could not pass the humidity tests. The specs required that Command Module subsystems be designed to operate reliably in 95% RH, but coatings and encapsulating materials capable of withstanding this level of humidity over the specified mission time simply were not available.

At about the same time, during one of the *Mercury* flights, it was reported unofficially that one of the urine bags in the spacecraft burst, causing severe damage to some on-board equipment. Then there were other reports that the

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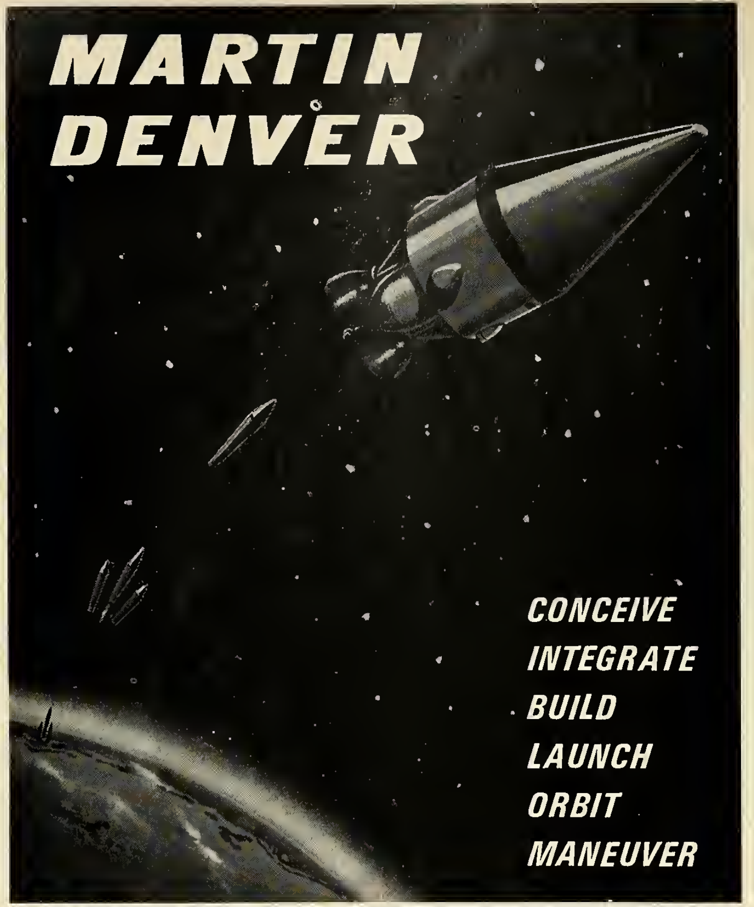

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astronauts themselves were resisting the in-flight maintenance concept on the grounds that it could consume an inordinate amount of their time.

More stringent packaging requirements were imposed on Command Module data and communications equipment, leading to the Block IB PCM telemetry package. Although the modular concept was dropped in Block IB, engineers at Radiation had to preserve the same configuration—two separate plug-in boxes weighing a total of 40 lbs. Each box has 1,200 external wire connections; because of the humidity problem each wire was internally sealed.

The modular in-flight maintenance concept was now eliminated. In its place was a new envelope design providing for an internally controlled environment. Each of the two Block IB units is controlled by valves having a low cracking pressure, with the inlet valve designed to "breathe" through a dessicant pack which controls internal relative humidity.

Unfortunately, the dessicant crystals proved to be a limiting factor. They could not absorb enough moisture to assure adequate reliability over the specified mission life. Internal relative humidity was a particularly critical factor in a high-impedance system such as Radiation's PCM equipment, says Hersperger.

Finally, North American Aviation, Inc., prime contractor on the *Apollo* Command and Service Modules, issued a directive last year calling for a complete redesign of the Command Module and its data and communications subsystems. New reliability and packaging factors were specified, and the demise of the in-flight maintenance concept was confirmed. The redesigned subsystems were designated as Block II and the PCM telemetry package was termed "mission essential."

The Block I phase of the PCM program ended prematurely with construction of six engineering and 15 development models. The final production phase was eliminated and the development units, including the one scheduled to fly aboard *Apollo 009* last week, were designated for *Apollo* suborbital and some orbital missions. Block II units were designated for later manned orbital rendezvous rehearsals and the *Apollo* lunar missions.

Block II—The Block II program provides for two pre-production (PP) units, three production qualification (PQ) units and 17 qualification (Q) units. Engineers at Radiation recently completed construction of both PP units, and these were the ones that underwent initial acceptance tests at Melbourne recently. The first PQ unit will go to Collins and the other two will be shipped to North American Aviation.

First delivery of Q units is scheduled for the second half of this year.

As part of the overhaul of Command Module subsystems, NASA and NAA altered the reliability requirements. The reliability factor rose from 0.963 for a 336-hour mission life for Block I to 0.9997 for a 200-hour mission life for Block II.

"We are allowed a certain number of failures (in Block II)," says Hersperger. "These include five analog channel failures out of a total of 365 channels and the loss of one group of eight digital channels." Block II has 212 digital channels, compared with 342 for Block I; the earlier model has 320 analog channels.

"The shorter mission time requirements for Block II (of 200 hours) apparently requires reliable systems performance to the point of departure from the lunar surface," says Hersperger. "Our PCM equipment is valued as mission essential to that point."

Block and component redundancy are utilized throughout the Block II hermetically-sealed package to meet the more stringent reliability factors, although total weight of the single Block II package exceeds the combined weight of the two Block I boxes by only about two pounds. If the required number of spare modules for in-flight maintenance were included in the overall weight of Block I, Block II would actually show a weight advantage despite the redundancy.

Borrowing from OAO—A quad-redundancy technique used previously by Radiation in the *Orbiting Astronomical Observatory (OAO)* was adapted to Block II. This provides for parallel redundancy of resistors, with capacitors, diodes and other components redundant in series-parallel. Under this concept, as many as three of the four parallel resistors could fail without knocking out the circuit, says Hersperger.

Block redundancy was used for the programmer, output shift register, analog-to-digital converter and power supply (although both power supply units can operate simultaneously or singly). In the dual redundant circuits, a "check circuit" constantly monitors the operational unit and automatically applies power to the "spare" whenever a failure occurs.

The Block II package contains 21,450 components—diodes, resistors, capacitors, transistors, chokes, transformers, etc. All components are welded onto card modules which are encapsulated in foam and soldered to printed circuit boards. The boards are stacked under compression inside pressurized, gasket-sealed humidity-proof packages. All 21 connectors are hermetically sealed to prevent leakage. Package dimensions are: Width 7.75 in., height 13.3 in. and depth 14.2 in.

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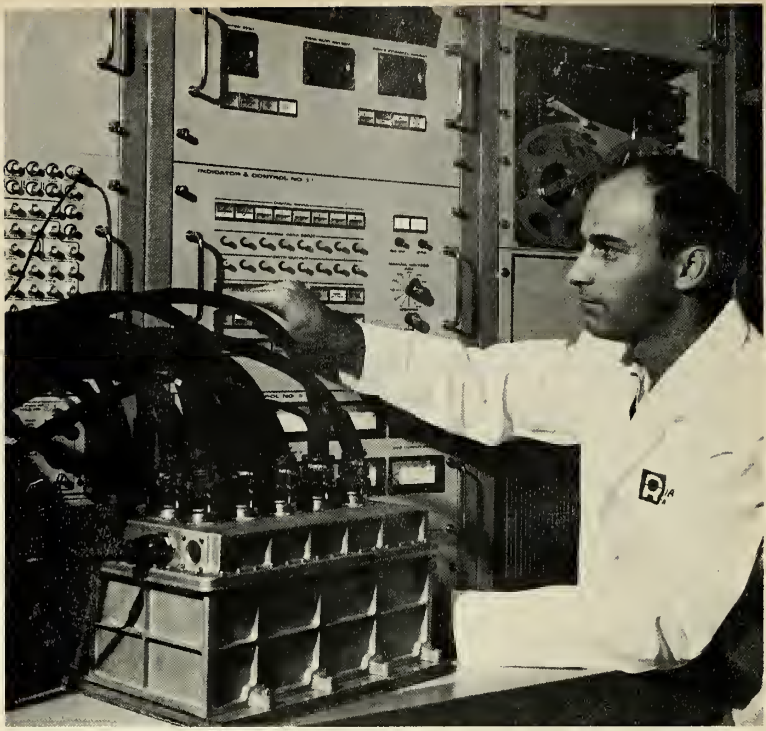

One of two pre-production units of Block II Apollo PCM telemetry checked out at Radiation, Inc. Checkout system was built for real-time data checks on both blocks.

The PCM subsystem multiplexes all input data and provides spacecraft output data in a serial Non-Return to Zero (NRZ) form. The Block II telemetry package can be programmed externally to operate in a "normal" or "reduced" mode.

In "normal" operation, data output is provided at a 51.2-kc bit rate in the form of 6,400 8-bit words per second, with input data consisting of 365 high-level (0 to 5 volts) analog inputs, 304 paralled digital inputs and one 40-bit serial digital input word. A 32-bit sync/ID word and an 8-bit format identification word are generated inside the PCM package.

When operating in "reduced" mode, data output is provided at 1.6-kc bit rate in the form of 200 8-bit words per second. Input data for this mode consists of 100 high-level analog inputs, 288 parallel digital inputs and one 40-bit serial digital input word. Words generated internally are the same type as generated in "normal" mode.

Although designed as a high-level system, Block II will accept data from an external low-level (0-40 mv) subsystem.

Humidity sweat—Spacecraft humidity posed such a serious threat to equipment that the outer aluminum casing of the Block II PCM package had to be machined from a formed billet to create a sufficiently high level of metal density. According to Hersperger, casting of the case would have resulted in a relatively porous metal skin through which enough moisture could penetrate to threaten subsystem reliability.

As part of its contract on *Apollo* PCM telemetry, Radiation built checkout Unit Test Equipment which can be used for real-time data checks of both Block I and II. One of these units has been delivered to Collins Radio.

Caudill noted that Parameter Variation Analysis of the units was required under the contract, employing a digital computer. These studies resulted in a number of "sound design changes," he said.

Hersperger said that although Block II represents more advanced thinking on the problems of spacecraft moisture and reliability, the earlier Block I development units apparently have performed quite well. "We have yet to get a report from the field on any failures," he said.

Both Radiation, Inc. experts emphasize that humidity in the spacecraft was the greatest single problem confronting designers, and one that was not clearly foreseen at the outset of the *Apollo* program. The solution of this problem led to subsystem designs which probably will have considerable impact on future manned space missions. ■

RCA Outlines World Watch On Weather

LOS ANGELES, CALIF.—By 1975, communications for the World Weather Watch System will have to be carried by a satellite system. Until then, conventional communication links can be used.

Engineers from Radio Corp. of America told the 1966 Winter Convention on Aerospace and Electronic Systems here that a synchronous satellite system would be able to serve all countries with weather information from world meteorological centers. A conventional system, however, would be limited in capability. Speakers from the Systems Development Office of the Weather Bureau told the convention that the pressing need for this decade is extension of weather observations from the present 20% of the world to full global coverage. The World Weather Watch is intended to meet this need. It will be truly global and will systematically exploit new developments in space technology, communications, data processing and meterological instruments.

The RCA studies, carried out by H. M. Gurk, M. P. Rehm, and P. F. Stebe, centered on the communications problems of collecting weather data from manned or automatic stations on land or sea, and from other types of stations such as constant level balloons drifting in the atmosphere. To be useful, the global data should be collected and sent to World Weather Watch processing centers and to each nation within an hour.

All numerical processing for global analyses and forecasts will be done at three world meteorological centers, located at Washington, D.C., Moscow and Melbourne, Australia. The three centers will produce the same outputs, available to all nations.

Two methods studied—Two types of information distribution were considered in the RCA studies. In one, analyses and forecasts are transmitted in digital form to communications hubs. There they are converted to graphic form and redistributed to meet national needs, as far as conventional communications allow. In the second, available

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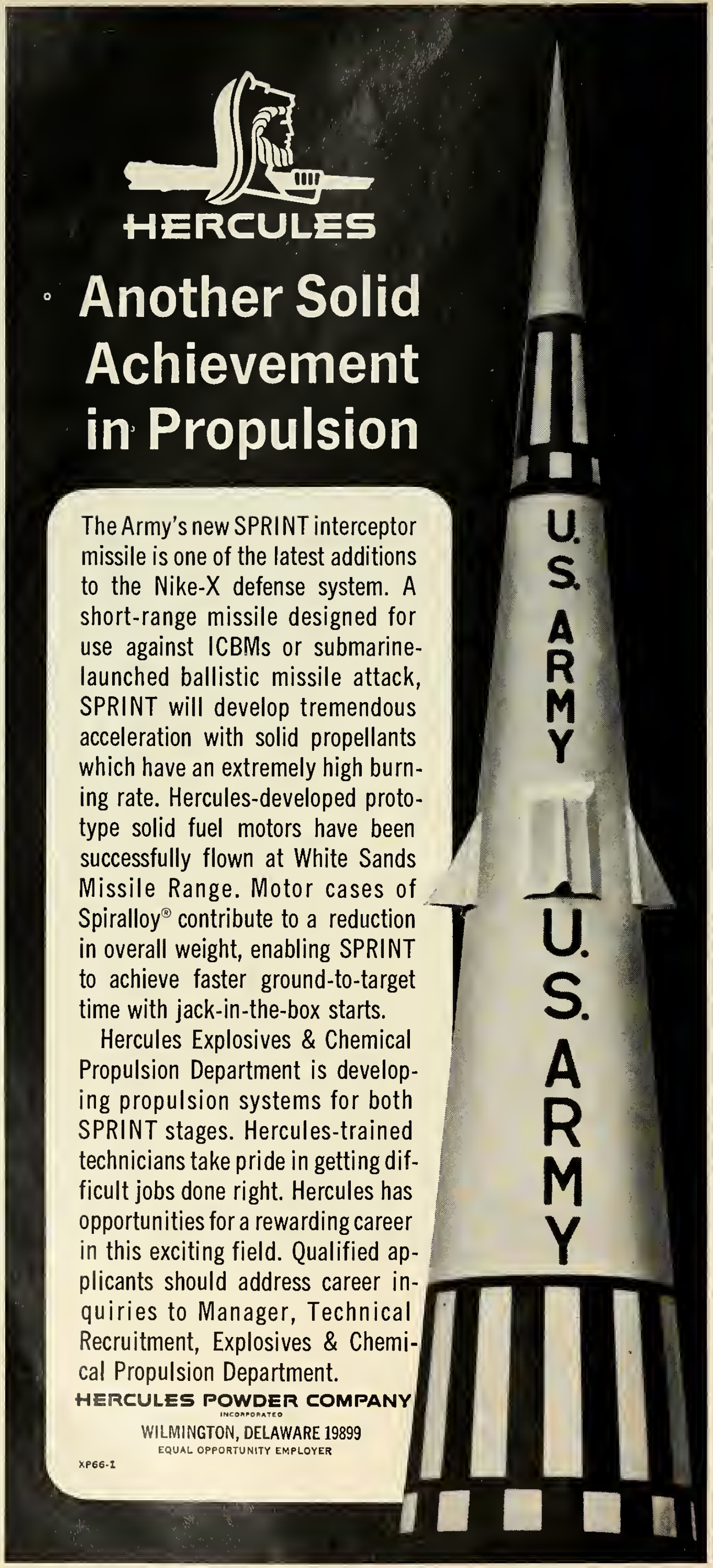

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Between the late 1960's and 1975, the number of global charts put out by each of the three centers is expected to rise from 30 to 75, distributed twice per day. The charts would have a digital grid-point data format with 120,000 characters per chart.

The satellite system chosen to handle the communications requirements of the weather watch was comprised of four synchronous satellites. A four-transponder multiple-access satellite was selected for both collection and distribution of data. Three of the transponders would carry the output from the three world centers. The fourth would be used for data collection and include SSB-FM conversion.

Normally data from a center's transmitter would be directed to a single satellite. Successive relays in a single direction, using only one transponder for the output of the world center, would transmit the data to all receivers in the combined areas of coverage of the four satellites. Four ground relay stations would be required.

Two-way operation possible—If a satellite should fail, the single-direction communication would be changed to a two-way operation, some data going clockwise and some counter-clockwise, with one center transmitting in both directions. During distribution, the data-collection transponder would be used for multi-channel, multiple-access teletype for system monitoring.

Four voice channels per world center would be used, allowing three to four-hour distribution of the heaviest load expected.

Data collection would be carried out by a 50-channel multiple-access system, with frequency control being supplied to the instrumented platforms by tones sent from the satellite. On command, a platform would respond, at a low rate, on the proper channel with data and location information.

Location would be measured by means of relayed signals from U.S. Navy's VLF Omega System. Mobile platforms would transmit telemetry and omega signals to a satellite in a single-sideband mode. The combined data would be transmitted from the satellite to relay points on the ground on a low-deviation FM link.

At relay points, a computer system would convert received data to a standard code for distribution and also process the received omega signals. After batching, the data would be sent to all users through the three satellite transponders, and the center ouputs would be phased into these links at different times. ■

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Aircraft ground support unit A/M32A-60 uses AiResearch gas turbine to produce AC and DC power and compressed air. Units were designed and produced by Wolverine Diesel, additional units produced by Libby Welding.

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Publication Date: March 28, 1966
Closing Date: March 14, 1966

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Accelerometer Calibration Simplified

A DEVICE easily made from generally available machine shop items will provide static calibrations of accelerometers in the ± 1 g range to accuracies within 0.0004 g units.

Designed and assembled at the National Bureau of Standards by Paul S. Lederer and John S. Hilten, the unit can be duplicated by any user of accelerometers—providing the ultimate in reliability without requiring the user to rely on the Institute's calibration services.

The extensive use of accelerometers in the missile/space industry has burdened the NBS calibration facilities. This approach may ease the problem.

The procedure uses the tilting support method and involves the Earth's gravitational field as a reference. The instrument is mounted on a device showing orientation in the Earth's gravitational field, from which the component of the field producing a measured accelerometer output can be computed.

The calibration procedure is as follows: the accelerometer's electrical output is measured for 1 g (accelerometer sensitive axis vertical), for sequential positions to 0 g (axis horizontal), for positions to —1 g (axis 180° from 1 g position) and with continued rotation back through 0 g to 1 g.

At each position, the accelerometer should indicate the component of gravitational acceleration acting on it precisely g multiplied by the cosine of the angle between the vertical and the sensitive axis of the accelerometer.

Present machine shop technology permits this angle to be set with great accuracy. Instruments to calibrate accelerometers with reference to the Earth's gravitational field can be bought ready made, or assembled as was done at NBS.

The calibrator at NBS consists essentially of a machine-shop dividing head, modified by adding a bracket for holding the transducer and resting on a machine-shop surface plate.

A complete description of the apparatus may be obtained from the Supt. of Documents, U.S. Government Printing Office, Wash. D.C. 20402; NBS Tech Note No. 269, Feb. 14, 1966, "Earth's Field Static Calibrator for Accelerometers". ■

RELIABILITY ENGINEERS

BSEE or BSME-Reliability design review:
Experienced with small electrical components and semiconductors. Prepare procurement, test and design specifications.

BSEE-Reliability analysis:
Experienced in circuit design and analysis. Perform detailed reliability analyses of complex electronic parts and circuits and recommend improvements in design reliability.

BSEE-Reliability test engineering:
Prepare test procedures for electrical and electronic packages and coordinate procedures with test laboratories, conduct proofing of test procedures and test equipment.

BSME-Reliability and inspection:
Perform mechanical and structural reliability analyses. Provide for inspection planning and review prints to determine inspection attributes. Experience in metallurgy and NDT helpful.

Non-destructive testing:
Background in electronics and applied physics plus knowledge of instrumentation related to the use of X-rays, sound waves, electrical fields and optics.

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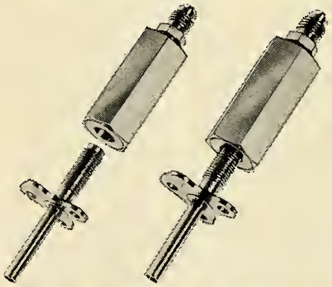

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*L = Low cost, R = Research and development, E = Efficient manufacturing, and Q = Quality throughout.
If your specifications are exacting, check Romec.

THE ROMEC FACILITY of LSI is the only major pump manufacturer in continuous production of all four basic pump structures . . . gear, vane, centrifugal and piston. Other fluid handling systems such as heat transfer units, quick disconnect couplings, hydraulic power packages, pressurization units, pressure switches, valves, and actuators are designed, qualified, and produced by Romec for aerospace, ordnance, ground, and marine vehicles. Unusual design problems, low cost, and reliability are Romec specialties. Write for literature.

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contracts

AIR FORCE

$4,000,000—General Dynamics Corp., Convair Div., San Diego, Calif., to refurbish and update 23 *Atlas* ICBMs for research and development flights.

$3,200,000—Sylvania Electric Products, Inc., New York City, to manufacture components and spare parts for advanced airborne data-processing equipment.

$1,900,000—General Dynamics Corp., San Diego, Calif., initial increment to a fixed-price contract for modification launch facilities for use in advanced ballistic re-entry systems (*ABRES*) program.

$1,424,540—Aircraft Armaments, Inc., Cockeysville, Md., letter contract for engineering and production of fault detector testers.

$241,687—Avco Corp., Electronics Div., Cincinnati, Ohio, for investigation of an infrared tactical air support concept.

$184,000—Space-General Corp., El Monte, Calif., for *MOL* experiment S-6.

ARMY

$17,000,000—Radio Corp. of America, Camden, N.J., for work on classified electronics equipment.

$5,888,450—Hughes Aircraft Co., Fullerton, Calif., for four satellite communications terminals.

$1,400,000—Cubic Corp., San Diego, Calif., to produce two additional ground stations for the geodetic satellite surveying program.

NAVY

$5,724,474—Western Electric Co., Inc., New York City, for classified oceanographic research.

$5,362,026—North American Aviation, Inc., Rocketdyne Div., McGregor, Tex., for Mk 39 Mod 1 rocket motors.

$4,700,000—Clevite Corp., Ordnance Div., Cleveland, for R&D of guidance and homing system for the Mark 48 torpedo.

$4,000,000—Beech Aircraft Corp., Wichita, Kan., for the continued production of the AQM-37A (KD2B-1) supersonic missile target. The AQM-37A is an air-launched, liquid rocket propelled vehicle capable of speeds of more than two times the speed of sound at altitudes of 70,000 feet or higher.

$2,500,000—Lockheed Aircraft Corp., Sunnyvale, Calif., for work on a classified project.

$2,000,000—International Telephone and Telegraph Corp., Federal Labs, Nutley, N.J., for support of the AN/URN-20 TACAN (tactical air navigation) program.

$1,826,000—Raytheon Co., Space and Information Systems Div., Waltham, Mass., for *Polaris* guidance equipment.

$1,108,251—General Electric Co., Ordnance Dept., Pittsfield, Mass., for Mk 73 mod 1 gun and guided missile directors and ancillary equipment. Also, $750,000 for R&D on *Tartar* director Mk 73 SAM improvement program.

$695,861—Stroz Industries, El Cajon, Calif., for *Polaris* transponders.

$599,934—Bunker Ramo Corp., Canoga Park, Calif., for R&D of an air-transportable sonar surveillance system.

$548,063—Maxson Electronics Corp., Macon, Ga., for missile and ordnance components.

$437,500—American Bosch Arma Corp., Garden City, N.Y., for field engineering services for technical assistance in installation, servicing, testing and repair of underwater weapons fire-control equipment.

$400,000—Bendix Corp., Mishawaka Div., Mishawaka, Ind., to accelerate level of R&D effort on *Talos* RIM 8-E guidance control and airframe.

$199,996—Space-General Corp., El Monte, Calif., for R&D on a microwave sensor for missile guidance.

$107,475—Value Engineering Co., Alexandria, Va., for engineering services on design concept of rocket motor inert parts, *Tartar, Terrier* frame.

NASA

$1,100,000—Grumman Aircraft Engineering Corp., Bethpage, L.I., N.Y., to complete its work on the *Apollo* lunar landing program.

$1,000,000—General Dynamics Corp., Convair Div., San Diego, Calif., from Lewis Research Center for *Atlas* launch services.

$499,888—Bendix Corp., Bendix Systems Div., from Marshall Space Flight Center for lunar surface mobility systems comparison and evolution study.

$400,000—Avco Corp., Research and Development Div., follow-on funding to continue work on unmanned scientific satellites to probe the atmosphere of Mars and to study the adaptation of one such vehicle to take atmospheric readings of Venus. Also, $116,000 additional funding on a contract from Ames Research Center that will enlarge upon a recently completed assignment to evaluate the feasibility of a small probe vehicle to communicate data on the Martian atmosphere back to Earth.

$147,406—Lockheed Aircraft Corp., Sunnyvale, Calif., from Lewis Research Center for *Orbiting Astronomical Observatory-G* and *Orbiting Astronomical Observatory-2* program definition.

$103,930—Bendix Corp., Bendix-Pacific, North Hollywood, Calif., from Goddard Space Flight Center for acoustic transponders.

INDUSTRY

$23,400,000—General Electric Co., Syracuse, N.Y., from **Bell Telephone Labs, Inc.**, New York City, for design, development, fabrication and installation of radar beam-forming and steering equipment that forms part of the receiver for the *Nike-X* system's multi-function array radar (MAR).

$980,000—Varian Associates, Palo Alto Tube Div., Palo Alto, Calif., from **Hewlett-Packard Co.**, Palo Alto, Calif., to provide microwave tubes for use in electronic test instruments.

$500,000—Atlantic Research Corp., Alexandria, Va., from **General Dynamics Corp.**, Pomona Div., Pomona, Calif. for engineering services for the *Redeye* anti-aircraft missile.

$240,000—Page Communication Engineers, Inc., Washington, D.C., from **Dynatronics, Inc.**, Orlando, Fla., to deliver and install support equipment for Pacific Missile Range tracking antenna systems.

$131,000—International Telephone and Telegraph Corp., ITT Gilfillan, Los Angeles, Calif., from the **Royal Netherlands Air Force** for ground approach radar and associated electronics.

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INSTRUMENTATION (EXPERIMENTAL OPERATIONS)—BSEE—to plan, specify, design, and develop instrumentation for measuring a great variety of physical phenomena during both airborne, and ground test of aircraft and missile equipment. Experience should be in areas of analog and digital data acquisition systems, automatic data reduction equipment, and related equipment.

SENIOR EXPERIMENTAL ENGINEERS—to undertake varied assignments on mechanical systems involving heat exchangers, rotating machinery, hydraulic and/or pneumatic equipment. Should have experience in devising and conducting environmental tests for structural and performance evaluation, and preparing component specifications for tests, manufacture and procurement. Requires knowledge of thermodynamics, heat transfer and/or hydraulics, pneumatics and electricity.

ANALYTICAL ENGINEERS—with experience that has emphasized analytical studies in thermodynamics and heat transfer. Familiarity with environmental system concept, analysis and trade-off studies. Knowledge of turbine, fan, compressor, and heat exchanger design and test analysis.

ADVANCED PLANNING ENGINEERS to conduct preliminary design and program studies, prepare and present new product technical proposals in the fields of spacecraft environmental controls, life support systems and hardware, as well as planning, coordinating and directing technical sales effort of new aerospace proposals.

RELIABILITY ENGINEER—to analyze reliability needs and reliability stature of proposed mechanical space equipment and Ground Support Equipment, to improve the simplicity and stress-strength margins of such equipment. Requires ME with experience in reliability studies or design or development of mechanical aerospace equipment.

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New Product of the Week: Molecular Gas Laser

A continuous-wave gas laser, said to be five times more powerful than any previous model, has been announced by Perkin-Elmer Corp.

The Model 6200 molecular laser uses a mixture of carbon dioxide, nitrogen and helium gases to produce a minimum of 10 watts, multiple mode, of continuous energy at a wavelength of 10.6 microns (middle infrared).

The laser can deliver controlled power to a small area, providing up to a million watts/sq. cm., the firm says. It has a 10-mm-dia. output beam; operating efficiency is 5%. For safety and convenience, the beam is folded 90° by an optical attachment which directs the energy down onto an asbestos sample platform. A micropositioner accessory permits movement of a sample under study.

The unit has a self-contained power supply with input of 115v ac, 60 cps.

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Signal Line Isolator

The Bunker-Ramo Corp. has developed an all-solid-state signal line isolator that uses an optical system to couple timing, control or data signals between input and output circuitry.

Extraneous signal attenuation of the Model 9900100 is over 100 db in forward and reverse directions from dc through 25 gc. Digital signals may be transmitted at rates from dc to 100 kc.

The isolator consists of an optical coupling system employing an emitter and sensor separated by a conductively and electromagnetically shielded interface. Input and output circuits are provided to match system input and output characteristics. The unit meets all government specifications for its type.

Circle No. 152 on Subscriber Service Card

Torquing Gyroscope

A torquing two-axis gyroscope that does the work of two integrating rate gyroscopes has been announced by Humphrey, Inc.

The FG 23 series has torquing rate capabilities of up to 20°/sec. It features a dc-ac-dc pickoff system with no wiping contacts. The unit is linear within ½°.

Circle No. 153 on Subscriber Service Card

Circuit Test System

An integrated circuit test system which provides automatic testing and data recording on circuits having up to 16 leads has been announced by Aerotronic Associates, Inc.

The Model 613 includes five operational amplifier-type power supplies. Three of these supply either positive or negative outputs and constant current or constant voltage operations. A digital comparator provides double-ended limits and a go/no-go indication to the data logger. Test data consists of the test number polarity, three digits of readout, the decimal multiplier and a letter signifying constant current or constant voltage operation.

Circle No. 154 on Subscriber Service Card

Impedance Accelerometer

Kaman Nuclear has announced a variable impedance accelerometer that provides acceleration measurements from ¼ to 5,000 g's with 1% accuracy.

Model KA-1100 provides a high-frequency response while maintaining ability to measure static or steady-state accelerations, the firm says. Output resolution is continuous; high overranges can be applied without affecting calibration.

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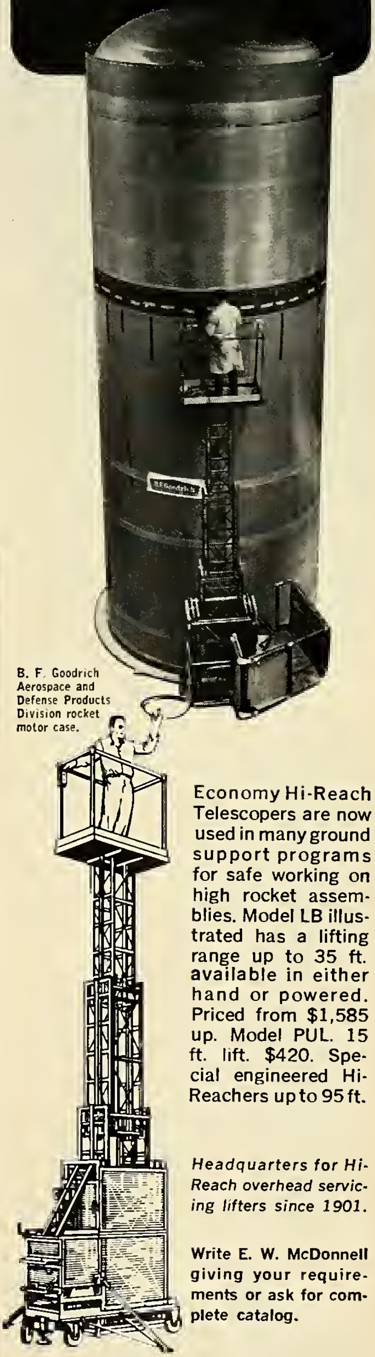

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Dr. Lloyd Morrisett: Elected to the board of trustees of System Development Corp. He is president of the Carnegie Foundation for the Advancement of Teaching.

David E. Weiss: Appointed vice president of B & F Instruments, Inc. In the late 1950's he founded his own company, which developed and manufactured autopilot accelerometers and related instrumentation. The firm was sold to Gulton Industries Inc., in 1963.

George C. Tweed, Jr.: Named vice president of engineering for Cubic Corp. He has directed development of Cubic's aerial and geodetic satellite surveying systems and battlefield target location systems.

James S. Sims, Jr.: Joined Bowles Engineering Corp. as vice president in charge of research and development. He has been granted several patents for inventions in the aerospace field.

Robert E. Miller: Appointed vice president for contract management at Melpar, Inc. He holds patents on a direction finder and multichannel communications systems.

Charles F. Harde: Appointed special assistant to the president of Avnet, Inc. He will coordinate the research required for the company's acquisition and merger programs.

Charles R. Sublett: Appointed vice president of Elpac, Inc., and general manager of the firm's systems division. He will have complete responsibility for the division's administrative, engineering manufacturing and marketing activities.

William E. Bushor: Appointed vice president of International Data Publishing Co. He will serve as editor-in-chief of *Laser Focus*, and publication manager of *EDP Industry and Market Report.*

William D. Rollnick: Named vice president of finance and administration of Data Technology Corp. He was formerly director of marketing at Fairchild Instrumentation.

O. P. Young: Elected president and director of Lytron, Inc. Prior to joining the company, he was vice president and engineering manager of a foreign subsidiary of Ebasco Services, Inc.

Raymond Azar, Gerald Bradley, James Crawford, Wilton Parker: Elected to the board of directors of the Garrett Corp. All four are officers of the corporation.

J. Robert Ferguson, Jr.: Named vice president of engineering appropriations of the United States Steel Corp. **S. P. Curtis** was named vice president of design and construction. **Patterson S. Weaver** was appointed administrative vice president of long-range planning and new product development.

Frederick W. Hesse II: Named senior vice president of TRW Systems Group. **Dr. Edward B. Doll** was also named a senior vice president. They both have held executive positions in the company for more than 10 years. **Herbert C. Knortz:** Elected a senior vice president in addition to his current duties as comptroller of International Telephone and Telegraph Corp.

Max Singer: Elected president of Hudson Institute, Inc. He has been counsel and treasurer of the company and will continue as treasurer and a member of the institute's board of trustees.

Ray R. Eppert: Appointed chairman of the board and chief executive officer of Burroughs Corp. He has been with the corporation for 45 years and has served as president of the company since 1958.

Nelson C. Harnois: Named vice president of marketing for Cubic Corp. He was formerly corporate director of marketing for the firm.

G. W. Bates: Appointed vice president of engineering of Dynair Electronics, Inc. **F. P. Ciambrone** was named vice president of operation and **P. R. Seng**, vice president of finance.

John D. Couturie: Appointed executive assistant to the vice president and general manager of Hughes Aircraft Co. His former position was assistant treasurer and asistant director of finance.

George R. Seeger: Named manager of the air-launched missiles advanced programs at the Bendix Mishawaka Div. **Norman K. Peters** was named manager of surface-launched missiles.

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MARCH

National Conference on Space Maintenance & Extravehicular Activities, sponsored by the Air Force Aero Propulsion Laboratory Research & Technology Div., and the Martin Co., Robert Meyer Motor Inn, Orlando, Fla., March 1-3.

10th Scintillation and Semiconductor Counter Symposium, sponsored by the Institute of Electrical and Electronics Engineers Nuclear Science Group, Shoreham Hotel, Washington, D.C., March 2-4.

The American Institute of Aeronautics and Astronautics Technical Committee Plasmadynamics Conference on Plasma Measurements and their Interpretation, U.S. Naval Postgraduate School, Monterey, Calif., March 2-4.

Third Annual Southeastern Symposium on Government Contracts, sponsored by the Mid-Florida Chapter, National Contract Management Assn., Cherry Plaza Hotel, Orlando, Fla., March 3-4.

Electrical Engineering & Operation Conference, sponsored by the Pacific Coast Electrical Assn., Sheraton Palace Hotel, San Francisco, March 3-4.

Conference on Space Economics, sponsored by the American Institute of Industrial Engineers, Canaveral Chapter, Ramada Inn, Cocoa Beach, Fla., March 5.

American Congress on Surveying and Mapping and American Society of Photogrammetry Convention, Washington Hilton, Washington, D.C., March 6-11.

Geometric Optics Seminar-in-Depth, sponsored by the Society of Photo-Optical Instrumentation Engineers, White Sands Chapter, Hilton Inn, El Paso, Tex., March 7-8.

Third Space Congress, sponsored by the Canaveral Council of Technical Societies, Cocoa Beach, Fla., March 7-8.

Electric Propulsion Meeting, sponsored by the American Institute of Aeronautics and Astronautics, San Diego, Calif., March 7-9.

Western Metal & Tool Conference and Exposition, sponsored by the American Society of Metals and American Society of Tool & Manufacturing Engineers, Los Angeles, March 7-11.

Electronic Industries Assn. Spring Conference, Statler Hilton Hotel, Washington, D.C., March 7-10.

1966 Spring National Convention of the Society for Nondestructive Testing, Biltmore Hotel, Los Angeles, March 7-10.

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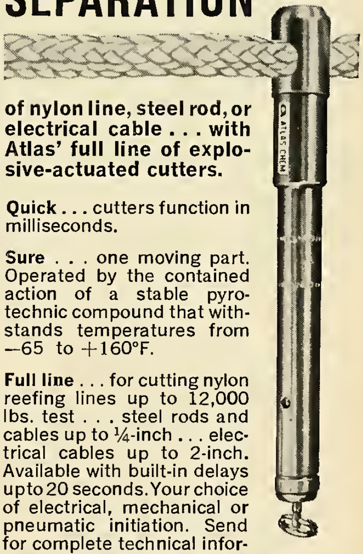

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None If By Sea

BRITAIN'S DECISION to buy the swingwing F-111 on credit and to phase out the Royal Navy's air arm is one that will have far-reaching consequences.

It is virtually a death knell for that nation's once-proud aircraft industry, an industry that gave us radar, the jet engine, the first jet airliner, the angled deck carrier and many other innovations.

But the matter actually goes far beyond that. Accompanied by the decision to sharply cut back forces in the Middle East and elsewhere, it marks the end of Britain's long-held position as a first-class world power.

Anyone who doubts this need only contemplate the Labor Government's decision to allow the Royal Navy's force of five aircraft carriers to go out of service by the 1970's because Britain cannot afford to build, man and maintain a new carrier fleet. For a nation whose pride and glory was in seapower, this is indeed the end of the line in world politics.

It is not at all surprising under the circumstances that both the Navy Minister and the First Sea Lord have resigned. It is rather astonishing that the whole Navy has not quit.

The decision is difficult to understand in the light of lessons being learned in the Vietnam theater. With the prospect that limited wars may be with us for some time—in the Far East, Middle East, Africa and even South America—it would seem that an effective naval air arm would be just the need to protect far-flung British interests. Despite dismantling of her colonial empire, the United Kingdom maintains a prosperous commercial establishment throughout the world. Trade is still the vital lifeblood of the U.K.

Carrier aviation remains an excellent way of showing the flag in troubled areas, and as the U.S. carriers off the coast of Vietnam are so well demonstrating, is an effective way of dealing with trouble when it does break out.

The fact is, however, that Britain has no interest any longer in participating in such affairs as the Vietnam conflict. Undergoing a new prosperity at home, she is content to let the Americans, Australians and others fight the battles that in the long run are of prime importance to British holdings in Singapore, Malaysia and elsewhere.

Defense Minister Denis Healey explained to the House of Commons that the White Paper was an exercise in realism. It appeared to be much more an exercise in economy and damn the consequences.

Navy Minister Christopher Mayhew, in outlining the reasons for his resignation, appeared to be much nearer the mark when he called the $5.6-billion ceiling on defense expenditures "purely artificial" and denounced it as "too small if we want to stay east of Suez, too much if we don't."

He argued that carriers were needed to support an east-of-Suez position because they would provide assurance against losses of bases, they would allow Britain to use air power in any part of any ocean, they possessed proven deterrent power, and they were extremely flexible in meeting unpredictable situations. All quite true.

He also warned that if Britain stayed in Asia on a reduced budget, the result would be to reduce the U.K. to a mere extension of U.S. power. Again, quite true.

The Navy Minister summed it up well when he noted "something totally incongruous in a nation carrying out a proud function—peacekeeping—on borrowed money. The sound of our gunpowder will be drowned by the rattling of the collection box."

WHAT DOES ALL THIS MEAN to the U.S. industry? In the long run, it means a larger domestic defense market, for the U.S. will have to meet those commitments which Britain is too weak and too unwilling to meet. It also means less competition in the foreign market from a dwindling British aerospace industry.

Despite the bait which U.S. Defense Secretary McNamara held out in the F-111 deal (enabling Britain to compete without discrimination for certain U.S. defense contracts), the Labor Government's decision to buy American hopelessly weakens the British industry. Just why the British are so willing to trust Mr. McNamara, who appeared previously in their defense history as the fiend incarnate of the *Skybolt* cancellation, remains a mystery.

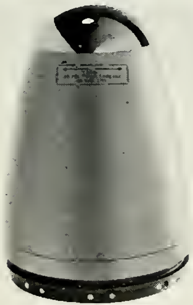
We trust, however, that no one in U.S. industry will trouble to complain at the short-run competition which this may provide on a few inconsequential contracts. The net effect of the White Paper decisions will be to put the finishing touches on an industry which once appeared as a potentially potent competitor.

To have accomplished this, and to have sold the F-111's at the same time, is an act of statesmanship worthy of the Marquis de Sade.

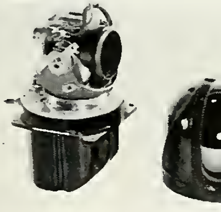
William J. Coughlin

INFRARED ENGINEERS AND SCIENTISTS:

Can you contribute to the development of products like these?

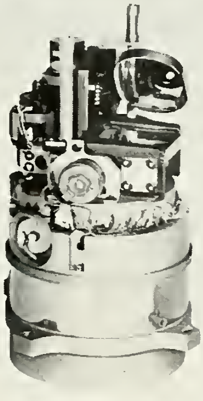


Homing guided missile seeker head.



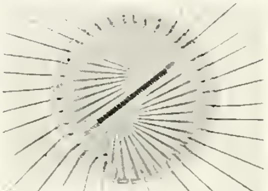
Interceptor IR search/track set.

Anti-tank missile controller.

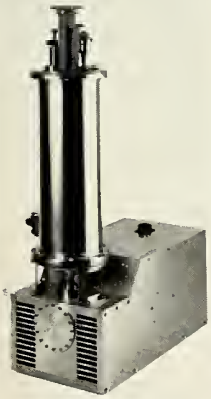


Star tracker for SURVEYOR spacecraft.

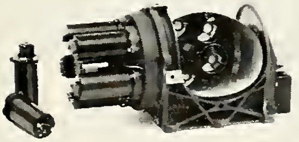
Miniature closed-cycle cryogenic refrigerator.



36-element IR detector array.



Cryogenically cooled parametric amplifier.



Radiometer for NIMBUS weather satellite.

Multi-element cooled IR detector.

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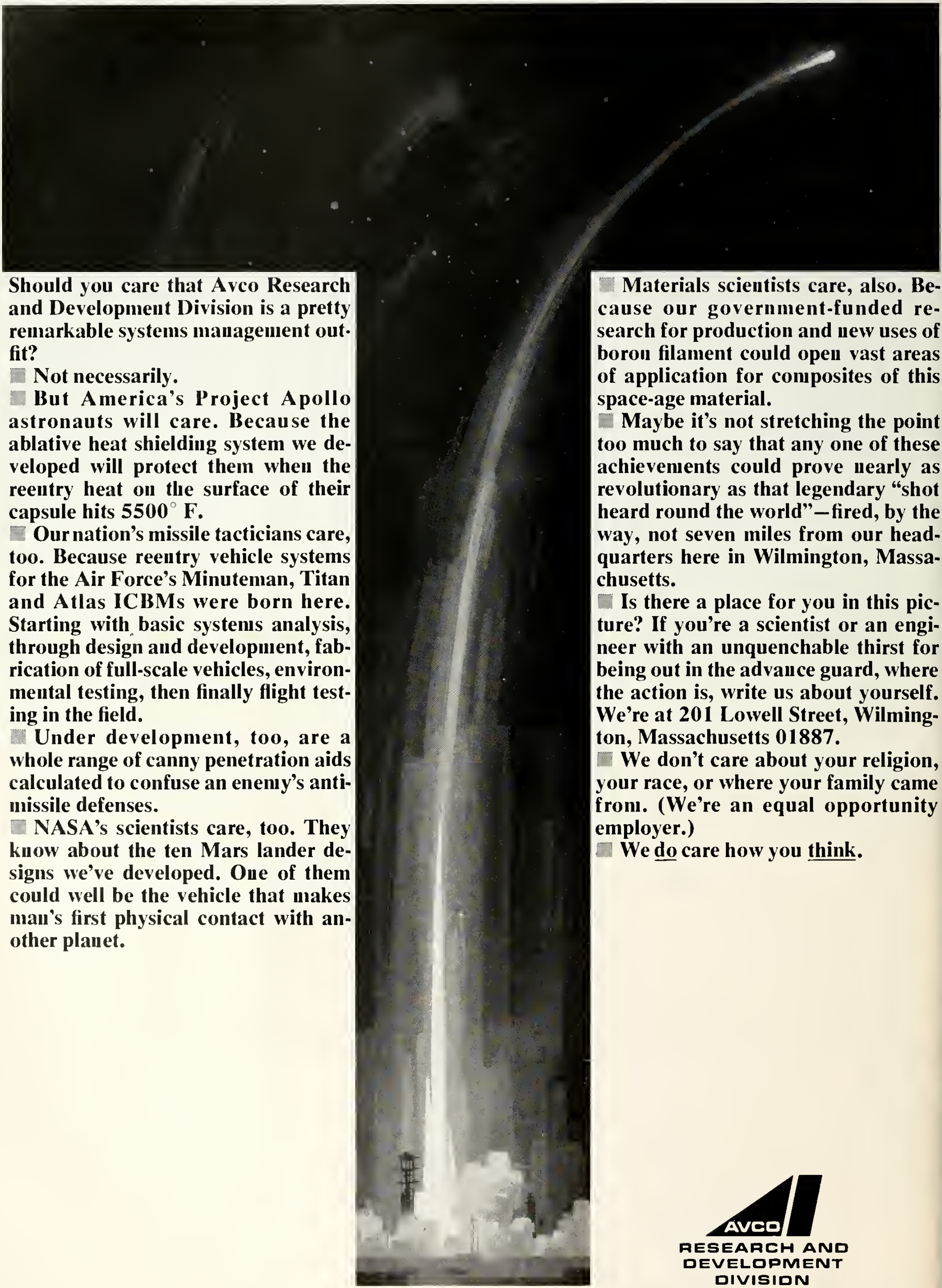

Should you care that Avco Research and Development Division is a pretty remarkable systems management outfit?

Not necessarily.

But America's Project Apollo astronauts will care. Because the ablative heat shielding system we developed will protect them when the reentry heat on the surface of their capsule hits 5500° F.

Our nation's missile tacticians care, too. Because reentry vehicle systems for the Air Force's Minuteman, Titan and Atlas ICBMs were born here. Starting with basic systems analysis, through design and development, fabrication of full-scale vehicles, environmental testing, then finally flight testing in the field.

Under development, too, are a whole range of canny penetration aids calculated to confuse an enemy's antimissile defenses.

NASA's scientists care, too. They know about the ten Mars lander designs we've developed. One of them could well be the vehicle that makes man's first physical contact with another planet.

Materials scientists care, also. Because our government-funded research for production and new uses of boron filament could open vast areas of application for composites of this space-age material.

Maybe it's not stretching the point too much to say that any one of these achievements could prove nearly as revolutionary as that legendary "shot heard round the world"—fired, by the way, not seven miles from our headquarters here in Wilmington, Massachusetts.

Is there a place for you in this picture? If you're a scientist or an engineer with an unquenchable thirst for being out in the advance guard, where the action is, write us about yourself. We're at 201 Lowell Street, Wilmington, Massachusetts 01887.

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MARCH 7, 1966

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

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Pegasus Satellite
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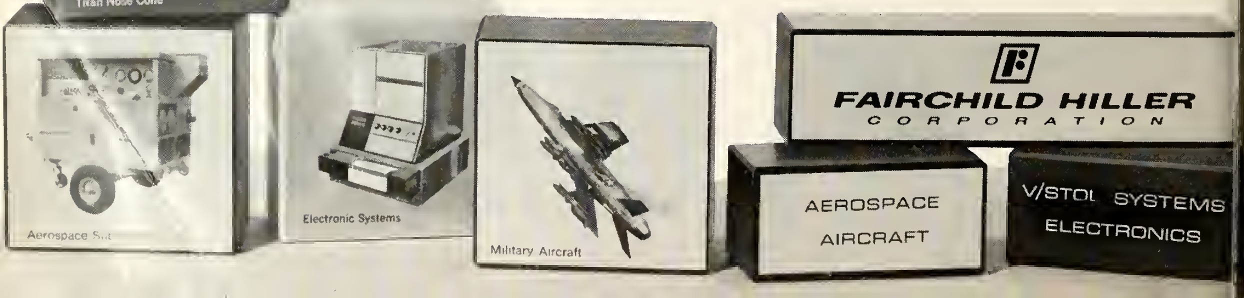
Some of the basic building blocks in Fairchild Hiller's pattern of growth are displayed here. With few words they tell of special competency in aerospace design and development . . . military and commercial aircraft . . . operative and advanced V/STOL systems . . . and electronics from ground to galaxy.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THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 18, Number 10 March 7, 1966

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THE COVER

Two Minuteman ICBM's are shown just after leaving Vandenberg AFB silos in salvo launch Feb. 24. Simultaneous launching tested multiple firing techniques that could be used at operational bases under combat conditions. SAC crews from Malmstrom AFB made the double launch.

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letters

Once and Future Things

To the Editor:

A high point in my Saturday afternoon reading at the office is the issue of your excellent magazine. The editorial in the Feb. 21 copy ("Once and Future Things") is excellent, and I commend you for it. I am, of course, pleased to have you give the added attention to the President's Annual Report (to Congress on the space program) which, as you undoubtedly know, we made ready for him.

Dr. Edward C. Welsh
Executive Secretary
National Aeronautics
and Space Council
Washington, D.C.

Marine Tactical Data

To the Editor:

May I offer my belated congratulations for your very fine article, "Marine Tactical Data System Detailed," by Rex Pay, in your Feb. 21 issue.

Since it appeared, I have heard many plaudits from our Data Systems Division and from U.S. Marine Corps Offices as well. It is not often that we see such a comprehensive article on as difficult a subject as this is, but you certainly have grasped the essence of the program. The Marine Corps was pleased because it brought to their public the fact that they are fully abreast of the state of the art.

Jevne Haugan
Manager, Public Relations
Data Systems Division
Litton Systems, Inc.
Van Nuys, Calif.

Digging In on the Moon

To the Editor:

The problem discussed in your excellent Feb. 14 editorial ("An Ill Wind . . ."), as well as other letters and articles, is not so much one of space technology as of human psychology, mainly that of government bureaucrats who say it can't be done. This whole *Ranger* and *Surveyor* boondoggle hinges upon the assumption that conditions on the Moon must be determined before sending up men, whereas almost every new development has proven the opposite. The gloomy forebodings in regard to weightlessness, disorientation, etc., have simply not materialized. Men can take care of themselves in space much better than machines. And even if not, the unmanned craft can determine the bearing strength of the lunar surface only at the places where they land, and adequately so only if they are as heavy as the manned vehicles to be sent up later. The lunar crust may vary greatly from place to place, requiring an impossible expenditure of time and funds to attain complete certainty.

The standard objection to immediate manned landings—safety—would not apply with private groups not accountable to world opinion, and such groups would probably devise all sorts of subtle, ingenious and money-saving methods for circumventing difficulties. But even under NASA, why cannot crews be kept alive bogged down in dust pockets or lava tubes till help arrives—when much longer periods of exile in space are contemplated as a perfectly normal feature of interplanetary travel? Will not an enforced sojourn of a few weeks or months on the Moon in fact give training and experience for these longer periods of isolation? I cannot for the life of me understand where the difference lies, and NASA should be held to the point until it gives an explanation. Perhaps there is a reason, but we cannot see it from here!

Theodore Dufur
Los Angeles

Air War in Vietnam

To the Editor:

I have recently read an advertisement in M/R announcing your issue devoted to "the lessons of Viet Nam." As my VF squadron operates from a carrier, there are a couple of questions that cross my mind.

Will M/R put out the same "McNamara-oriented propaganda" about the air war over North Vietnam? Will M/R fall into the trap of reporting only what the senior officers have been told is the "party line" about the air war in Viet Nam?

Or—will M/R be the first to report the true facts on how military aviators are hanging their necks out each day *in combat* and not being permitted to do their jobs?

This could be the best and hardest story to tell about this "non-war" we are fighting. I hope that you will tell it all.

Name Withheld on Request
Commanding Officer

None If by Sea

To the Editor:

Britain is giving up its claim to major military prowess simply to survive economically. What good would it do the nation to build five aircraft carriers for the Royal Navy and then not have the money to sustain the pound when necessary, maintain government services, or tend to its commercial commitments abroad?

True, Mr. Coughlin, Britain would like to have new aircraft carriers, TSR.2 strike fighters—even our former world status. We are not despairing when we say we cannot afford the former items, or rewrite history for the latter. We are as realistic as the United States is when it sets up its budget in terms of the country's ability to come up with the money and survive.

F. R. Smythe
Toronto

SYSTEMS
RELIABILITY MILESTONE:
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In September, 1963, an inertial guidance system began its vigil inside one of America's Minuteman I missiles.

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The Minuteman I guidance system, built by North American Aviation/Autonetics, has proved so reliable the components have established standards for U.S. military and space applications.

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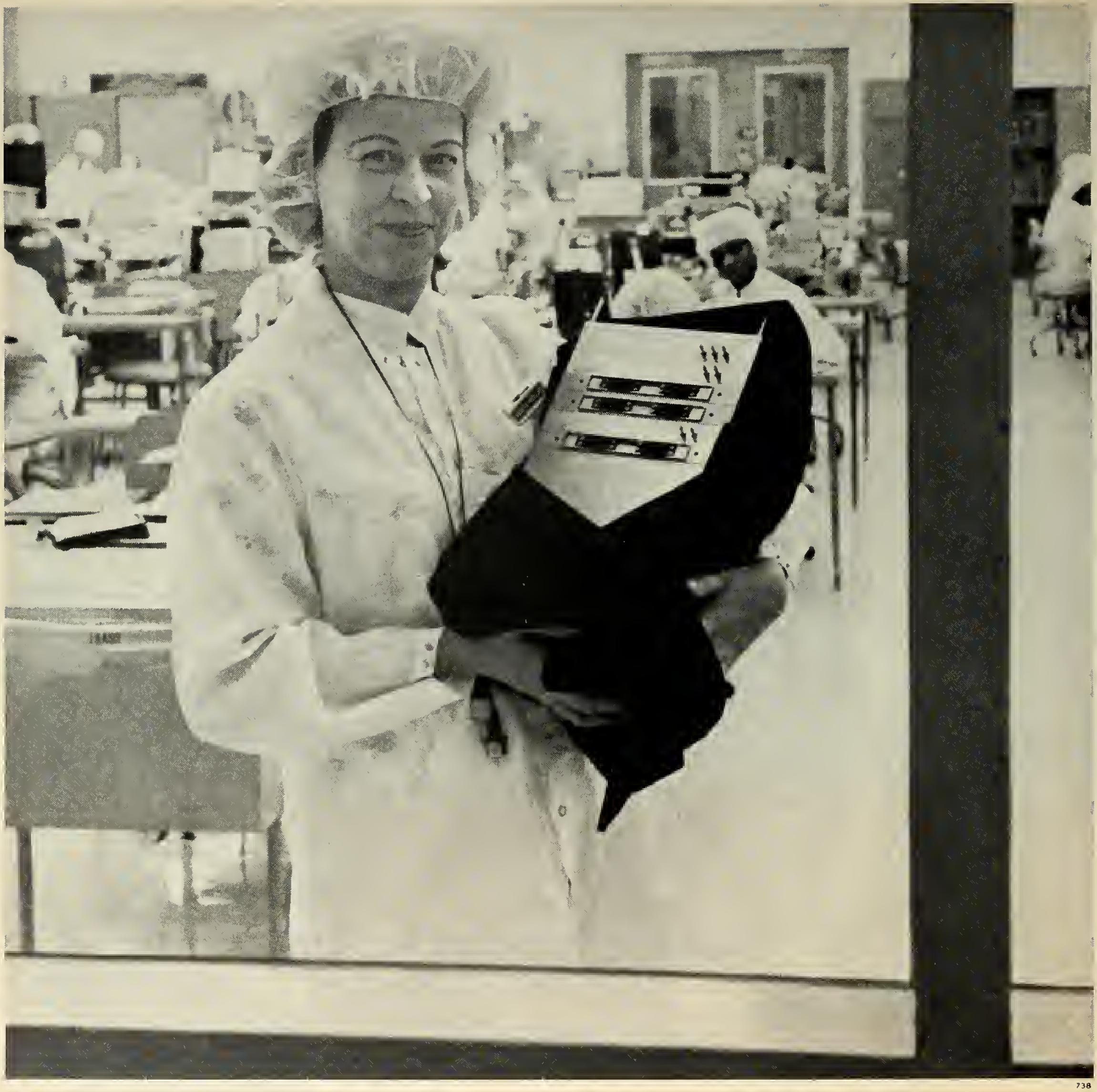
North American Aviation Autonetics Division



738

Our newest baby

This one is called SGLS. It is a standardized, S-band, TT&C system, the most versatile of all Space Ground Link Systems for manned and unmanned vehicles. The modular Digital Telemetry Unit is shown above. It's work like this that creates technical and administrative openings in Inertial Guidance and Control Systems; Communications; Spacecraft Heat Transfer; Electric Space Power; Digital Systems; Human Factors; Electro-optical Systems; Scientific Programming; Applied Mathematics; Aerodynamics; and Management Systems Development; Financial Analysis; Contract Administration; Writing of Technical Proposals. Why not write us. TRW Professional Placement, One Space Park, Dept. B-31, Redondo Beach, California. TRW Systems is an operating group of TRW Inc., a company diversified in the fields of aerospace, automotive and electronics. TRW is an equal opportunity employer, male and female.

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The Countdown

WASHINGTON

Congress Concerned over Military Space

There is growing concern in Congress over the increasing pace and success of the Soviet space program, with particular apprehension over developments in military areas. Result may be pressure for a speedup in the *Manned Orbiting Laboratory* programs and for a considerable expansion in other portions of Air Force space efforts—possibly a revival of interest in new satellite interceptor concepts.

First Flight of Lifting Body Set

First flight test of the *M-2* lifting body vehicle now is scheduled for early next month. It will be preceded this week by a captive test flight on March 7 in which the *M-2* will be carried aloft by a B-52 bomber, but not dropped.

Army Studies Missile Support

Dept. of Army officials have begun meetings at the Army's Missile Command at Redstone Arsenal, Ala., to study and improve support problems connected with Army missile systems, particularly the so-called high-dollar, low-density missiles. Study, expected to continue for several months, is headed by Brig. Gen. T. T. Paul.

Apollo Pallet Contract Expected

NASA selection of a contractor to build the *Apollo* Experiment Pallet is expected in 30 to 45 days. Four firms —Lockheed, McDonnell, Martin and Northrop—are competing for the award. Pallet will be used to hold various experimental payloads.

House Moves Fast on NASA Bill . . .

House Space Committee subcommittees are expected to vote this week on the NASA FY 1967 authorization bill, bringing their recommendations to the full committee next week. Space Sciences and Applications Subcommittee probably will be ready to vote Tuesday or Wednesday, and Advanced Research and Technology shortly thereafter. The Manned Spaceflight Subcommittee was expected to begin executive deliberations late last week.

. . . And Gets Busy on DOD Budget

Congress now is getting down to serious work on the FY '67 Dept. of Defense budget after passing the Vietnam supplemental pretty much as requested by the Administration. House Armed Services Committee begins March 7 with Secretary McNamara, while hearings already have begun in the Senate Armed Services Committee.

FCC Returns ABC TV Satellite Request

Federal Communications Commission has returned American Broadcasting Co.'s request to set up its own satellite system until interested parties can comment on the question of domestic operation of non-common carrier satellites by non-government groups. Comments are due Aug. 1. Comsat Corp., which considers it has sole authority to operate commercial satellites in the U.S., has scheduled an April meeting with the broadcast networks to consider television's need for satellite communications.

NASA, AF Agree on Biosatellites

Air Force has reached agreement with NASA to have the space agency handle all its requirements in the animal satellite area, possibly through *Biosatellite* follow-on flights or through the *Apollo* Applications Program. NASA now is studying how best to meet the Air Force requirements in this area.

Army Plans Four SECOR Launches

Army is planning four launches of the *SECOR* satellite during FY 1967, according to information received by the House Space Committee. Members of the Space Sciences and Applications Subcommittee plan to question the need for these launches, since NASA's *Geos* satellite program is labeled as the national geodetic satellite project.

McNamara Angered by Stennis Views

Rift is growing between Secretary of Defense McNamara and Sen. John Stennis (D-Miss.), a long-term veteran of defense affairs and member and/or chairman of all three key Senate military committees. McNamara is furious over insistence by Stennis that requirements in Vietnam have almost exhausted the U.S. reserve of trained and ready active military forces. The Secretary feels serious miscalculations by the enemy could result from these statements, and similar reports in the press, which he emphatically insists are erroneous. *(See related item, p. 8.)*

Minuteman Not Seen as Scout Replacement

Surplus *Minutemen* do not appear to be a good replacement for *Scout* launch vehicles for space probes, according to early reports from a NASA study still in progress. Problems which lessen its cost-effectiveness relate to the need for another stage and other modifications.

INDUSTRY

Agena Engine Completes Six Firings

The *Agena* engine for the *Gemini* docking mission has completed six ignition firings at a simulated altitude of 380,000 ft. in the test chamber at the Air Force's Arnold Engineering Development Center. Mission simulation firings were scheduled to begin late last week and are to be completed by March 10. NASA believes modifications to the engine—following the explosion on Oct. 25 during the *Gemini 6* mission—have solved the problem. The space agency is planning to launch *Gemini 8* on March 15 as scheduled.

INTERNATIONAL

French Continue Missile Tests

Testing of components of the French *SSBS* missiles is now under way at the Centre d'Essais des Landes (near Biscarosse), where one stage of the French ballistic missile was launched recently from an underground silo. *SSBS* is due to be operational with the French Air Force in 1968 and will be based in Southeastern France in underground silos.

The Missile/Space Week

Stennis Scores 'Parrots'

Sen. John C. Stennis (D-Miss.), chairman of the Senate Preparedness Subcommittee, has lashed out sharply at what he considers to be the less-than-candid testimony of high-ranking military officers before closed sessions of Congressional committees.

Stennis said Congress can only act intelligently in defense affairs "if it has access to all of the facts and to the professional opinions and views of skilled and high-ranking military officers. There must be no arbitrary restrictions or institutional constraints which prevent these officers from presenting both the facts and their views to Congress openly, candidly, and freely."

Speaking before the Reserve Officers Assn. in Washington last week, Stennis referred to a memorandum issued last January by the Secretary of Defense in which, Stennis says, "Defense Department witnesses were given instructions as 'guidance' in testifying before Congress if pressed for their personal opinions which might not support the official decision."

Among other things, the senator reports that witnesses were told "to give the consideration of factors which support the decision," meaning the official decision of higher authority, according to Stennis, "in an attempt to compel the witness to argue for a viewpoint with which he disagrees."

Stennis called the directive "ridiculous," said it was restricting Congress to one-sided presentations which merely parrot officially approved positions, added that he will not be bound by these restrictions, and said that he would insist upon direct and responsive answers from the military when he requests personal professional opinion. "I will protect the witness, but as a senator," he said, "I will ignore the restriction."

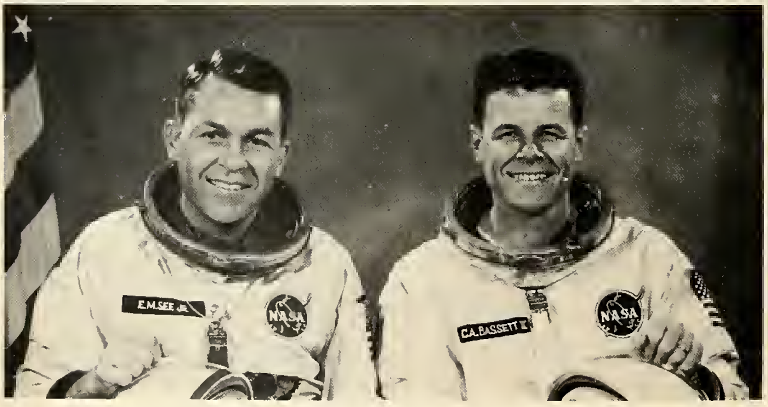
Congressional observers say that Stennis's remarks indeed reflect a wide concern over this matter extending through military committees in both houses of Congress. It also reportedly is strongly opposed privately by the military officers involved.

Venus Contamination Feared

NASA officials have urged Russian scientists to make public the steps they took—if any—to sterilize the Soviet spacecraft which crashed on Venus March 1.

U.S. scientists fear that the planet may have been contaminated by an inadequately sterilized spacecraft and that the only organisms future probes find may be those transplanted from Earth.

Edgar M. Cortright, deputy associated administrator for space sciences and applications, indicated that Russian technology would be far more advanced than expected if the Soviets were able to adequately sterilize the entire 2,000-lb. spacecraft. He said it was still not clear whether the Russians had impacted a whole craft or landed only a small, more easily sterilized portion of it.



Astronauts See and Bassett Buried in Arlington

Astronauts Elliot M. See, Jr., left, and Charles A. Bassett II, killed when their T-38 jet trainer crashed on landing at McDonnell Aircraft Corp., were buried March 4 in Arlington Cemetery. Bassett, an Air Force major, and See, a civilian, had been named primary crew for the Gemini 9 mission, scheduled for this summer. Backup pilots Maj. Thomas Stafford and Lt. Cmdr. Eugene A. Cernan will replace the two men. Astronaut Alan B. Shepard, Jr., will head a team investigating the crash.

SNAP-8 Spending To Rise

SNAP-8 spending may more than double by FY '68, according to Harold B. Finger, director of the AEC-NASA Space Nuclear Propulsion Office.

Finger told a hearing of the House Subcommittee on Advanced Research and Technology Feb. 25 he expects the spending to rise from this year's $4 million to some $8 to $10 million in FY '68.

Spending on the space nuclear power system dropped from $19.15 million in FY '65 to this year's low. NASA is now asking for $5.5 million for the project, indicating that the drop in dollars has bottomed out.

For FY '67, NASA plans to work on the power-conversion system development, leading to the eventual development of a 10,000-hr. working capacity, Finger said.

Mariner Experiments Chosen

Seven scientific experiments have been chosen by the space agency for its 1967 *Mariner* fly-by of Venus.

A modified version of the backup spacecraft for *Mariner IV*, which flew within 6,000 mi. of Mars in July 1965, will be used for the mission. The 530-lb. spacecraft will be launched by an *Atlas-Agena* in early summer of 1967 on a trajectory which will take it within 3,000 mi. of the planet.

The experiments are:

—Ultraviolet photometer—This experiment will use two ultraviolet photometers to attempt to produce a temperature profile of the upper atmosphere of Venus by measuring density and distribution of atomic hydrogen and atomic oxygen.

—S-Band occultation—This experiment will study the changes in *Mariner's* 2,300-mc carrier signal before and after it passes behind the planet. The experiment, similar to one conducted during the *Mariner IV* Mars fly-by, should indicate the density-altitude profile of the Venusian atmosphere and ionosphere.

—Dual-frequency radio occultation—Signals of two different fre-

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quencies will be beamed from Stanford University's 150-ft.-dia. antenna at Palo Alto, Calif. to the spacecraft. The effect of the planet's ionosphere and atmosphere on the signals received by *Mariner* will be studied for further information on the Venusian atmosphere and ionosphere.

—Trapped radiation detector—This experiment will observe particles of various energies to search for trapped radiation belts around Venus and to increase knowledge of energetic particle emissions from the Sun.

—Helium vapor magnetometer—This experiment will attempt to determine the strength and direction of the magnetic field of Venus as well as the flow of the solar wind around the planet.

—Plasma probe—This experiment will employ a Faraday cup detector unit to study the density, velocities, temperatures and direction of low-energy protons that stream outward from the Sun to form the solar wind.

—Celestial mechanics—This experiment will use Deep Space Network tracking data from the *Mariner* '67 mission and that from the 1962 *Mariner II* mission to Venus to further refine the astronomical unit, the masses of Venus and the Moon and the ephemerides of Earth and Venus.

ERC Construction Scheduled

Groundbreaking for NASA's Electronics Research Center in Cambridge, Mass., is scheduled for May, according to Boyd C. Myers, deputy associate administrator for operations in the Office of Advanced Research & Technology.

Myers told the House Subcommittee on Advanced Research & Technology that the master plan for the new research complex is running a year behind schedule, with construction running a year and a half late. However, he predicted that the first building would be in use by January, 1968.

Shots of the Week

NASA successfully fired the first *Apollo/Saturn IB* spacecraft from Cape Kennedy Feb. 26 (see pp. 14 and 33).

- *ESSA II*, the first meteorological satellite carrying automatic picture transmission equipment, was successfully launched from Cape Kennedy Feb. 28. The 285-lb. payload was boosted by a thrust-augmented improved *Delta* into the desired 750-n.-mi. circular orbit. The satellite began transmission of photographs of the Earth March 2.
- The Soviet Union launched *Cosmos 111* March 1.
- NASA on March 2 launched two rockets from Wallops Island, Va., to probe the upper atmosphere and ionosphere and send back data on solar radiation. An *Aerobee* carrying a 180-lb. instrument package from the Air Force Cambridge Research Laboratories was sent to an altitude of 142 mi. Five minutes later a four-stage *Javelin* carried NASA's first *Geoprobe*, a 185-lb. package with six experiments, to a peak altitude of 380 mi.

FY '67 Funds Complete Gemini

NASA's *Gemini* program will be wrapped up by FY '67 funds, Dr. George E. Mueller, NASA associate administrator, told the House Subcommittee on Manned Space Flight Feb. 2.

Mueller assured the committee that the present commitment of $1.354 billion would be enough to finish the program.

In response to a question by Rep. Emilio Q. Daddario (D-Conn.), Mueller said he considered the planned 12 *Gemini* missions the "bare minimum" needed just for pilot training for the *Apollo*.

Total cost of the *Gemini* program has topped the $1.217-billion runout cost set in FY '64. Mueller said the reason was technical problems with fuel cell development, spacecraft thrusters and booster actuators.

Aeronomy Probes Fired

Three U.S. Naval Research Lab probes powered by *Black Brant III* single-stage rockets gathered data on latitudinal and temporal variations in the turbopause in integrated launches from Eglin AFB, Fla., and Churchill Research Range, Canada, Feb. 21.

Two rockets were launched simultaneously. All carried 54-lb. payloads. The *Black Brants* are a development of Bristol Aerospace Ltd., Winnipeg, Manitoba, Canada.

The Eglin probe reached an altitude of 109 mi. with an 85° launch angle. The other two, fired from Churchill, achieved altitudes of 117 and 122 mi. with the same angle.

The *Black Brant III* measures 18.5 ft. long and 10.2 in. wide without the payload. Total weight of

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the launch vehicle is 630 lbs. The firings introduce the feasible use of single-stage aeronomy rockets—eliminating the operations involved in multi-stage vehicles.

No ITL for Vandenberg

The *Titan III-C* integrate-transfer-launch (ITL) facility at Cape Kennedy will not be duplicated at Vandenberg AFB, the Senate Space Committee was told in closed hearing last week.

Instead, informed sources told the committee that flights of the Air Force's *Manned Orbiting Laboratory* from Vandenberg will be made from an initial launch capability (ILC) site consisting of one pad.

Si-C Coated Filament Produced

Silicon carbide coated graphite or carbon filaments and yarn are now available on a limited basis from the Graphite Products Div. of the Carborundum Co.

The coating increases the oxidation resistance of the carbon materials to 3,000° F while adding significant improvements to interlaminar shear and compatibility with metal and resin matrices.

For instance, uncoated filaments lose their integrity after only 10 to 15 seconds in a bunsen burner flame. The coated material holds out for more than 10 minutes. There is an overall improvement in the elastic modulus of the coated composite since the carbide has a greater elasticity than the basic carbon substrates.

The materials should find applications in ablative shields and rocket nozzle components.

Present price structure—reflecting the limited production—runs from $150 for up to 4-oz. lots to $250 per lb. Increasing use will reduce the basic prices.

ATS Follow-On Studies Let

NASA has selected General Electric Co., Fairchild Hiller Corp. and Lockheed Missiles & Space Co. to study the feasibility of follow-on versions of the *Applications Technology Satellite (ATS)* for possible flights in 1969 and 1970.

The parallel six-month contracts, worth $150,000 each, would look into the technology needed by the satellites to telecast directly to home receivers, collect and relay data, and communicate with moving platforms. Some of these experiments are based on the present *ATS* program (see p. 22).

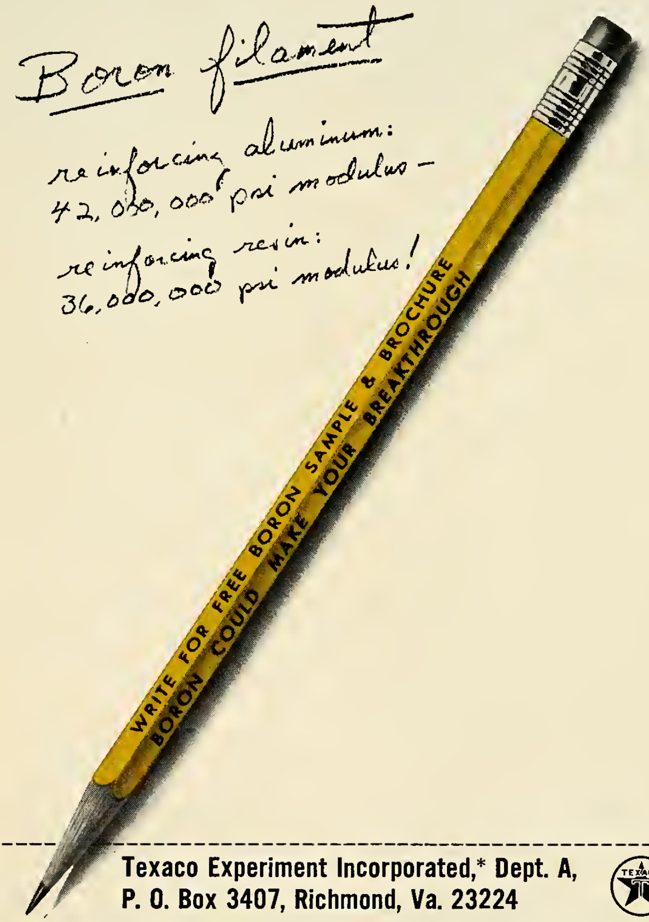
Other technical work named for the feasibility studies include studies of erectable antennas 30 ft. in diameter and larger, stabilization systems capable of 0.1-degree performance, phased-steered-array transceiver systems, and interferometers for spacecraft attitude determination.

The Air Force *Titan III-C* will be considered as a possible launch vehicle.

Comsat Seeks More Satellites

Communications Satellite Corp. has requested permission to build six advanced synchronous satellites for use in its global communications system.

Comsat's request, filed with the Federal Communications Commission last week, also asked for approval of the satellite's technical characteristics. TRW Systems will build the spacecraft under a contract now being negotiated (M/R, Dec. 20, p. 19). A synchronous orbit system was selected over a medium-altitude one because it "would be more reliable and provide greater system flexibility," Comsat said.



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Ballistic Missiles Ruled Out in Vietnam

New tactics, improved ECM equipment have cut aircraft loss rate that led to consideration of using HE warheads on existing missiles

by Michael Getler

ADVOCATES of a Defense Dept. development program to explore the tactical use of ballistic missiles with conventional warheads against targets in North Vietnam have apparently lost a battle to the Pentagon's cost-effectiveness measuring rod.

Interest in modification of existing U.S. surface-to-surface missiles to deliver high-explosive payloads to heavily defended targets in North Vietnam reached a high point last fall. Surface-to-air missile complexes were high on the list of potential targets after it became apparent that increasing numbers of U.S. aircraft were being shot down during runs against well-defended military sites.

Only a small number of U.S. aircraft were victims of Soviet-built *SA-2* surface-to-air missiles (SAM's), but their introduction was the first challenge to U.S. air superiority in the war in Vietnam. The threat forced U.S. planes to lower altitudes, bringing them within range of hundreds of conventional anti-aircraft guns, many of them radar-controlled (M/R, Oct. 18, p. 18).

At that time, open support for pursuing the potential of tactically used ballistic missiles as one way to avoid excessive aircraft losses in attacks against high-attrition-rate targets was voiced within DOD and the military.

Broad industry interest—The industry response, MISSILES AND ROCKETS has learned, was widespread, resulting in proposals from prime contractors for conventionally armed versions of virtually every surface-to-surface missile in the U.S. inventory. These included the Martin Co.'s *Pershing,* Sperry's *Sergeant,* Lockheed's *Polaris,* and even Boeing's *Minuteman.*

All proposals were prepared at company expense.

In the past several months, however, several factors have combined to dampen whatever support had been building to pursue development of this technique.

The principal elements have been the evolution of tactics that have considerably improved the ability of U.S. planes to evade the *SA-2* once it is launched, and the addition of improved electronic countermeasures equipment in these aircraft to warn pilots when a SAM radar is operating in their area.

Although there are still losses to enemy missiles and conventional gunfire attributable to the tighter envelope in which aircraft must fly, attrition rates have not been sufficiently high, in DOD's majority view, to warrant a modification program for ballistic missile use.

Furthermore, the Air Force and the naval air arm, charged with the principal responsibility for taking out targets in the North, have not come forward with any requirement for other than manned aircraft and air-launched weapons to do this job.

Finally, and perhaps most important, is what one well-informed source assesses as the "extreme tightness of new funding within DOD. They're scared they might waste a dollar."

The result, according to sources close to this situation, has been the unwillingness of DOD to fund, even at modest levels, the development of what many military men (mostly Army), industry scientists, and some DOD officials still feel is an option worth pursuing. It might then be quickly available in the future for use in Vietnam or elsewhere should defenses against aircraft increase or improve appreciably and unacceptable attrition rates rapidly develop.

Traditional mission arguments—The arguments concerning potential of ballistic missiles in this role tend to divide along traditional service lines.

For example, several high-level Army officers interviewed recently in Vietnam by MISSILES AND ROCKETS believe the technique is largely feasible, using either sea- or land-based missiles.

It requires, they believe, technical development that is within the state of the art, in combination with a national policy decision, which might prove harder to achieve.

Top-level Air Force officers in Vietnam, on the other hand, tend to view the prospect with much less certainty. They point to the expense of individual launchings and the very real problems of precisely defining target location for missile inertial guidance requirements.

If radar terminal homing is used, skeptics also point out the possible vulnerability to countermeasures developed by an enemy who has shown himself to be especially cunning regarding selective use of SAM radar broadcast. SAM search radars and those used for beam-riding guidance to the target are normally located at separated locations, which also complicates targeting problems.

One high-ranking Air Force officer estimates it would take a direct hit with a 2,000-3,000 lb. warhead to put a properly protected site out of commission. He also points out the problems of getting real-time reconnaissance inputs so that the site can be hit when it is manned and armed.

Supporters of the concept, both in and out of the military, agree that precise target location is a problem, but they also believe available technology can solve it. One expert told M/R "we have definitely turned the corner on the

AAP Telescope Responsibility Set

SELECTION OF a NASA center to handle the *Apollo* Applications Program (AAP) *Apollo* telescope mount (ATM) has been made by NASA headquarters and will be announced shortly, Deputy Associate Administrator Edgar Cortright has revealed.

Meanwhile, M/R has learned that Goddard Space Flight Center will direct the project. The Manned Spacecraft and Marshall Space Flight Centers also had been in the running. Total cost of the program, which would involve three flight units and a prototype, would be about $80 million.

Since the submission of the FY '67 budget request to Congress, he indicated the agency has made some adjustments leading to an item of $3.7 million for the ATM. This includes $2.7 million recovered from the cancelled *Advanced Orbiting Solar Observatory* program, and $1 million from the Manned Space Sciences Program.

Typical experiments, as suggested by Ball Brothers, one of the firms interested in the ATM, would include an ultraviolet spectrometer, X-ray telescope, and white-light coronograph.

state of the art required to do this entire job."

Actually, among supporters of further development, it is the warhead area that appears to merit most attention. Use of new cluster-type warheads is believed to be favored within DOD, as opposed to the single, larger designs. Associated work would probably be necessary on the heat shield and re-entry systems of any of the higher-speed two-stage vehicles that might be considered, such as *Pershing* and *Polaris,* in comparison to the single-stage *Sergeant,* which presents less of a re-entry problem but has a much shorter range.

Land system preferred—It is also believed that mobile land-based missiles are favored within DOD for this role, should it ever develop, as opposed to sea-based systems because their visibility makes them a greater deterrent to an enemy.

There are also other factors to be analyzed concerning possible degradation of strategic or tactical nuclear readiness to meet conventional warfare requirements.

For example, while *Polaris A-1* missiles, now out of active service, could be used, deployment might remove one or a number of fleet ballistic missile submarines from the strategic retaliatory force. There is also said to be some question as to whether or not the total number of *Pershing* missiles in the Army's inventory would allow removal of some as high-explosive warhead carriers without compromising nuclear force levels.

Political obstacle—In addition, there is the question of the potential political impact of introduction of long-range missiles, even with conventional warheads replacing the nuclear ones, into a limited, non-nuclear war that already has a long list of Administration-imposed ground rules.

Among those who feel there is sufficient merit in the potential of ballistic missiles in this role to warrant some advanced development support at this time by DOD, there is also the recognition that under present combat conditions their use would not be entirely cost-effective. There is, however, a strong feeling that "this is an additional capability the U.S. will someday pursue.

"We can't predict when and if aircraft attrition rates will get higher and tactical use of ballistic missiles will suddenly become cost-effective, or when the urgency and money will catch up with the idea," says one source close to the debate.

"Where there are a lot of options, you can't pursue them all, and this is definitely marginal at this time. However," he adds, "whether it is sound not to pursue marginal things when you can see a storm coming is another question." ■

Funds Considered for Mars '69 Landing Probe

by Heather M. David

A CONGRESSIONAL subcommittee may add funds to the Fiscal Year 1967 NASA budget to enable the space agency to include a landing probe on the *Mariner* Mars 1969 mission.

The House Space Committee's Space Sciences and Applications Subcommittee chaired by Rep. Joseph Karth (D-Minn.), is looking at the possibility of adding some $15 to $20 million in FY 1966 for the probe in the light of recommendations by NASA witnesses that the information that could be gained might considerably improve the chances of the 1973 *Voyager* landing mission, and possibly decrease the cost of the total program.

Time is a critical element in the program, however. As NASA Deputy Associate Administrator Edgar Cortright told MISSILES AND ROCKETS, the agency would have to have assurance almost immediately that it would get funding in the FY '67 budget, in order that certain definition activities could be initiated.

While the immediate work probably could be supported during this period, Cortright said, the agency still would have to know definitely that the addition of such funds would meet with Senate approval, and that the Administration would allow the funds to be spent.

The House Space Committee subcommitees finish their work this week, with a full committee vote on the NASA bill expected next week. However, House floor action, Senate action, and then actual appropriation of the funds by the Congress must take place before the outcome will be determined.

Estimated costs—Officials brought from NASA's Ames Research Center and the Jet Propulsion Laboratory for a special session to discuss the probe told the subcommittee that the total cost would be about $30 million, with $20 million of this needed in the FY '67 budget. NASA's earlier decision not to include money for the probe in its FY '67 request was purely budgetary, it was indicated.

First estimates by Avco Corp., which studied the problem for Ames Research Center, indicated that the probe could be developed at a cost of from $13 to $15 million. However, an intensive study at JPL, *Mariner* 1969 program manager Harris Schurmeier told the subcommittee, brought the estimate up to about $25 million. An additional $5 million, he said, would go to the fly-by spacecraft equipment, such as communications receiver, antenna, data storage and processing, and modifications to structure. About $5- to $8 million of the cost could be ascribed to the sterilization effort, he said.

Karth expressed his feeling that the *Voyager* program is being treated as a "stepchild," and that although it is the most ambitious project the Office of Space Science and Applications has undertaken, is not getting enough effort toward solving the obvious problems.

NASA officials outlined the advantages of obtaining the kind of information on atmospheric pressure and composition the probe could yield in 1969 as they would relate to the *Voyager* 1973 mission. If, for instance, it were proved that the atomspheric pressure were 7 mb instead of 4, the two limits generally accepted from the *Mariner IV* experiment, it would mean a difference of two or three magnitudes in the possible weight of the lander.

Both Ames Research Center and JPL are on record as favoring the probe, and witnesses Schurmeier and Alvin Seiff, chief of the vehicle environment division at Ames, indicated their personal support.

Avco study—Seiff told the subcommittee that two kinds of information could be gained from a probe, based on Ames work and a study done by Avco Corp. Through the use of accelerometers, data on the structural qualities could be determined, including density, pressure and temperature.

Composition of the atmosphere could be sensed by a radiometer experiment that would identify gases as they are heated by the shock wave in front of the vehicle, and through mass spectroscopy. Identification of the cyanogen radical by the former means is most interesting, Seiff said, since it would indicate the presence of nitrogen.

The Avco study, with which Ames concurred, estimated the weight of the landing capsule at 40-50 lbs., with the probe and sterilization canister adding up to 108 lbs.

While pressure information would be most applicable to the *Voyager* 1973 mission design, Schurmeier said, the composition data would have some input also, since this would determine the radiative heat exposure. ■

Manned Apollo To Fly This Year

A/S-201 success follows frustrating delays; two-pad launch capability will step up pace for remaining unmanned tests

by Hal Taylor

THE FLAWLESS PERFORMANCE of the *Apollo/Saturn IB-201* mission insures that this country will make a long-duration three-man space flight before the end of this year.

The first unmanned flight of NASA's most sophisticated spacecraft lifted off the pad at Cape Kennedy at 11:12 a.m. EST Feb. 26 and landed downrange at 11:51 after a 39-minute text-book flight.

The second unmanned flight, according to NASA officials, will be made early this summer. *A/S-203,* the third flight, will be made almost simultaneously because it will be launched from a different pad.

The first manned flight, NASA officials report, will then be made early in the fourth quarter of the year. The second manned flight in the series will probably follow in January, 1967. While the second flight conceivably could be made in December, a delay in delivery of the spacecraft reportedly is pushing it into next year.

The two-pad launch capability, using launch pads 34 and 37, both *Saturn* IB launch complexes, should also accelerate the *Apollo* flight program in the first quarter of 1967.

Frustrations mount—The successful initial unmanned flight followed a long series of delays caused by bad weather at Cape Kennedy and some hitches in the countdown that saw NASA officials in the embarrassing position of "scrubbing a scrubbed launch announcement," as one put it.

The launch was originally set for Feb. 23, but was delayed by cloudy skies and rain at Cape Kennedy.

As the count reached T minus 4 seconds Feb. 26, the launch vehicle shut itself down when there was an indication of low pressure in nitrogen tanks. Space technicians decided that there was no leak in the tank and that the pressure was sufficient for launch.

The count was recycled to T minus 15 minutes, but was again halted at T minus 7 minutes when there was another indication of low pressure in the tank.

After studying the problem for several minutes, NASA announced that the launch was scrubbed for at least 48 hours. The scrub announcement was then rescinded by Kennedy Space Center Director Kurt Debus, who decided that a series of tests indicated the problem was not in the launch vehicle but in a regulator in the ground support equipment and that the flight could be made successfully.

Booster delivers—The amazing performance of the *Saturn IB* on its maiden flight is illustrated by preliminary data indicating that actual burn and cutoff times hit the planned times almost on the button.

Actual burning time of the S-IB stage was 146.9 seconds, compared to the planned time of 146.5 seconds. Separation of the first stage and the S-IVB second stage was made at 147.7 seconds, compared to a planned time of 147.3.

Ignition of the second stage took place at 149.3 seconds, while the nominal time was 148.9 seconds. Cutoff of the second stage was 602.7 seconds compared to a nominal time of 592.6 seconds.

The launch vehicle performance was almost completely duplicated by the spacecraft. The only flaw in its flight was a slightly low burn of the Service Module engines. But Dr. Joseph Shea, director of the *Apollo* spacecraft development at the Manned Spacecraft Center, declared that he was satisfied with its performance. NASA late last week had no reason for the low burn.

The re-entry speed of the spacecraft reached 27,000 fps compared to a desired speed of 28,000 fps, but the test of the heat shield was declared successful.

The spacecraft impact point was 35 miles short of the nominal recovery area 4,630 miles downrange in the South Atlantic. It was recovered by the U.S. aircraft carrier Boxer at 2:13 pm.

The Boxer was scheduled to deliver the spacecraft to Norfolk, Va. March 6. From there it will be flown to North American Aviation's Space and Information Systems Div. Downey, Calif. plant. Space agency officials said it might be as long as a month before data is analyzed and final results of the flight are released. ■

Apollo 009 spacecraft's Command Module is recovered by personnel from USS Boxer after Feb. 26 ballistic flight.

Gemini 10 May Dock With Two Agenas

Summer flight may re-use Gemini 8 target vehicle as well as rendezvous with its own; new details of Gemini 8 mission

by Jinx Mercer

HOUSTON—*Gemini 10* pilots may rendezvous with two separate *Agena* target vehicles during their mission in mid-summer, MISSILES AND ROCKETS has learned.

The plan, which relies on the re-use of the *Gemini 8* target vehicle, and details of the upcoming three-day *Gemini 8* (March 15-18) mission were disclosed here last week.

Charles Conrad, Jr., and Richard F. Gordon, Jr., *Gemini 8* backup pilots, explained the *Agena* re-use plan.

The *Agena* launch time for the *Gemini 8* mission and all post-docking maneuvers are planned to place it in a good position for a possible future rendezvous and docking attempt by the *Gemini 10* crew, Conrad said.

The *Gemini 10* pilots will also attempt to retrieve a micrometeorite collection plate from the *Agena.* Retrieval of the experiment will depend on the tumbling rate of the "dead" *Agena.* Gordon said that if the vehicle is tumbling within "a couple degrees per second" retrieval may be possible.

The derelict *Agena* will be tracked by Mission Control Center flight controllers during ensuing months to accurately determine its position in space and compute its rate of decay.

Gemini 10 orbital maneuvers may then be planned to enable the pilots to seek out the lifeless target as a second or third rendezvous exercise.

It may also be possible, the crew hinted, for *Gemini 10* pilots to maneuver to the spent *Agena's* altitude—provided it is less than 210 n.mi.—hitched to their mission *Agena* and relying on its main engine for propulsion. Conrad explained that 210 n.mi. is the maximum altitude from which the *Gemini* can reenter on its own power without exceeding the safe heating limits of its heat shield.

The upcoming *Gemini 8* flight calls for two *Agena* propulsion system burns —one while the two vehicles are docked, and the other in undocked configuration.

Neil A. Armstrong, command pilot, and Major David R. Scott, pilot, will be teamed as the primary crew for the 70-hr. mission which will attempt a rendezvous with an *Agena* rocket, the first space docking, and extended extravehicular operations lasting through 1½ revolutions.

Scott will command the *Agena's* secondary propulsion system (SPS) 200-lb.-thrust engines to initiate a 20 fps out-of-plane burn, primarily to evaluate flexure at the mechanical coupling of the mated vehicles (M/R, Sept. 13, p. 18). The second *Agena* burn will be used to translate the spacecraft out of plane by some 1,500 ft. The 2-sec. burn will maneuver the *Agena* into a 220-n.-mi. circular orbit, where it will remain in position for the possible rendezvous with *Gemini 10,* Gordon said.

Other plans—Armstrong and Scott also disclosed other details of the *Gemini 8* mission.

The *Agena* target vehicle will be launched into a 161-n.-mi. orbit. The *Gemini* will lift off approximately 100 minutes later and will trail the *Agena* at orbital insertion by about 1,000 n. mi. *Gemini's* orbit will have an 87-n.-mi. perigee and a 146-n.-mi. apogee.

"We will take four orbits to rendezvous, utilizing the same techniques used during the *Gemini 7/6* mission," Armstrong explained.

The first docking will be attempted in the fifth revolution, approximately six hrs. and 30 min. into the mission. Armstrong will maneuver the spacecraft at maximum fps velocity into the docking adapter by aligning an index bar on the small end of the spacecraft with the V-notch of the *Agena* docking collar.

Docked, the two vehicles will be maneuvered as one for a comparison check of platform alignment accuracies and attitude and stabilization systems.

Armstrong explained that undocking can be accomplished one of three ways: by dialing the commands via the hardline to the *Agena* umbilical plug; by initiating a manual switching procedure through wires in contact with the target docking adapter; or by initiating a pyrotechnical device that explosively cuts the spacecraft free.

EVA schedule—Extravehicular activity is planned for the second day. The crew will depressurize the spacecraft

(Continued on page 40)

AAP Systems Definition Move Expected

NASA EXPECTS to select two or more firms about May 1 for the systems definition phase of the *Apollo* Applications Program.

The firms will be picked from among nine that submitted proposals to Marshall Space Flight Center Feb. 28.

They are Douglas Aircraft Missile and Space Div.; General Dynamics/Convair Div.; General Electric Defense Programs Div.; IBM Federal Systems Div.; Goodyear Tire & Rubber, Goodyear Aerospace Div.; Lockheed Aircraft, Lockheed Missiles & Space Co.; McDonnell Aircraft; Martin Co., Denver Div.; and TRW, Inc., TRW Systems Group.

Reportedly, Chrysler Corp. is teaming with TRW and the Boeing Co. is part of the IBM subcontractor group. Other teams are Douglas and RCA; McDonnell and Raytheon, and Martin and Bendix Corp.

Apollo Applications Program planning calls for up to 45-day Earth-orbital flights, 14-day exploration missions on the lunar surface and lunar orbital flights of up to 28 days.

It is the only NASA manned spaceflight program definitely scheduled to follow the U.S. *Apollo* program.

NASA has requested $42 million in Fiscal Year 1967 funds for the systems definition work and development of some experimental payloads. Together with some funding left over from FY '66, NASA expects to have about $100 million for the program.

Substantial hardware funding for the program is not expected until FY '68. One of the firms selected for the systems definition work is expected to be named the prime contractor for the program in the first half of next year.

From left to right: First four photos show 260-in. solid motor as ignition proceeds in 0.2-sec. increments. Last photo shows half-length unit operating in its steady-state thrust period, developing some 3.6 million lbs. of thrust at Aerojet-Dade.

Full-Length Big Solid Firing Backed

House Space Committee member indicates Congress disposed to underwrite additional FY '67 funding of some $7 million

NASA MAY RECEIVE sufficient additional Fiscal Year 1967 funding to fire a full-length 260-in.-dia. solid rocket motor.

Rep. Kenneth Hechler (D-W.Va.), chairman of the House Space Committee's subcommittee on advanced research and technology, told MISSILES AND ROCKETS that "I think there is a very good chance that we will approve funds for a full-length firing."

He said that while he had not polled members of his subcommittee—where the move to add money to the budget would be initiated—"I feel that there is considerable sentiment for pressing on with the program."

His comments were made as the space agency disclosed to the subcommittee that the decision to fire a third half-length motor—two have been fired successfully—was forced by budgetary constraints which allowed only a $3.5-million request in the FY '67 budget.

It is known, however, that NASA would prefer to scrap that plan and move to a full-length firing. This would cost an additional $7 million in FY '67 funds.

Hechler said that while he still did not know exactly how much additional funding would be needed for the full-length firing, "I think it would be a good move."

Hechler's backing will get the move to add funds off to a good start. In addition, both House Space Committee Chairman George Miller (D-Calif.) and manned spaceflight subcommittee Chairman Olin Teague (D-Tex.) favor the big-solid development program.

In Fiscal 1966, the subcommittee voted to give NASA $6.2 million more than the agency had asked for the program. This was ultimately approved by both the House and Senate when they voted on the final FY '66 authorization.

No TVC provided—The full-length firing would be accomplished by welding together the two half-length motor cases which were used in the two previous ground firings Sept. 25, 1965, and Feb. 23, 1966.

This would provide a thrust of 7 million lbs., but there would be no thrust vector control. This would require a 16-month lead time with a firing in calendar 1967.

While NASA ultimately would like to fire a full-length motor with thrust vector control, it is reportedly ready to go ahead with a firing without TVC because the Air Force is doing a lot of TVC development in its 156-in.-dia. program.

The firing of a full-length motor with TVC reportedly would cost about $23 million.

Rep. Dante Fascell (D-Fla.), representing the district in which Aerojet-General Corp.'s big solid plant is located, has asked the subcommittee to approve $20 million in FY '67 funds for the program.

He would increase the thrust by changing the grain pattern, provide TVC, and a full-length firing. It would be paid for entirely with Fiscal '67 funds. The firing could take place as early as the spring of 1968.

2nd-test data studied—Meanwhile, detailed analysis of the data provided during the second firing of a half-length 260-in.-dia. solid at Aerojet's Dade facility (see photos above) is now under way at the firm's Sacramento, Calif., computer complex.

The initial crude information obtained shortly after the successful test indicates that the actual pressure level and the shape of the pressure-time curve coincide with the predicted results. A variation of some 5% is to be expected in the final data reduction since only limited data reduction is possible at Dade.

Visual inspection of the nozzle and quick calculations by Aerojet's Dade experts also indicate that the ablation rate went as predicted. The predictions for this firing were considerably strengthened by experience with the first firing.

The quench system malfunctioned at the end of the test, and the resultant mild burning loosened the bonded doublers on the outside of the exit cone. The cone will not be re-used in the third firing because of this—NASA experts were not too enthusiastic about re-using the cone in the first place.

One additional layer of insulation was used in the interior of the massive case since faint discolorations were seen on the outside of the case after the first firing. There were no such hot spot marks after the second test. ■

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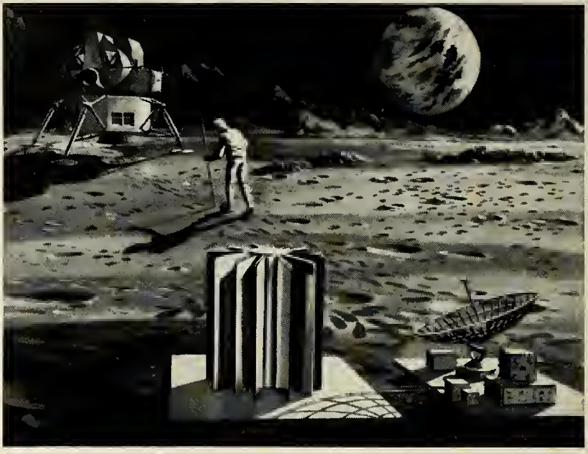

There's nothing easy about building the SNAP-27, a 50-watt, Plutonium-238 lunar generator which will provide the energy to transmit measurements back to earth for 6 months to a year. And the time schedule is just as snappy.

Although systems for nuclear auxiliary power aren't new (we've been studying and designing a number of SNAP programs for the last 2 years), this AEC contract is big news, especially when you think about the potential of nuclear power for deeper space missions and how it ties in with our business in spacecraft at Valley Forge.

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ELECTRONICS

Lightweight Radar Altimeter Readied

Westinghouse Defense and Space Center engineers will deliver a complete functioning prototype lunar radar altimeter to NASA's Marshall Space Flight Center next month. The operational unit may end up weighing only 8 lbs. through the use of tiny molecular electronic functional blocks in 80% of the circuits. Altitude range will be from 100 to 60,000 ft., with an altitude-dependent accuracy of ±1%. The prototype unit is being designed and built under a modification of a previous contract from NASA.

Light From Solid Semiconductor Crystals

Monsanto Co. is marketing visible light sources composed of solid semiconductor crystals for instrument signals, panel indicators, and computer applications. The lights emit a nearly monochromatic red, and under typical use conditions, operating at 1.6 volts, surface brightness exceeds 50 foot-lamberts with a current of 50 milliamperes. The light is brighter at higher currents. Since the device is a diode, light emission occurs only when the current flow is in the forward direction. Lifetimes of more than 10,000 hours can be expected with on-off times of 8 to 10 nanoseconds. The solid-state source is competitively priced.

PROPULSION

UTC Tests New Propellant Composition

A new chemical fuel ingredient which improves the burning characteristics of solid propellants has helped to deliver the highest performance of any known motor using non-toxic compositions. The test motor contained about 300 lbs. of propellant. United Technology Center Div. president Barnet R. Adelman said the new compound could increase both range and payloads of current solid rockets. The static firing was one in a series funded by the Air Force Rocket Propulsion Lab. Now in its third year at UTC, the program has so far contracted more than $1 million.

High-Density Propellant Fired

A propellant with a density greater than 0.12 lb./in.^{3} and a density impulse greater than 600 has been successfully test-fired at Rocket Research Corp. Developed by a team under Dr. David Good, the composition uses an off-the-shelf oxidizer to produce a non-detonable propellant. The formulation is particularly applicable to volume-limited motors such as those in air-launched and ship-launched missiles. The propellant is an in-house company development.

MATERIALS

Avco in Severe Environment

Tungsten/oxygen reactions and other gas/metal transformations are being evaluated at Avco Corp.'s Research and Advanced Development Div. under a $150,000 follow-on contract from Air Force Systems Command's Research and Technology Div. The program will refine measurements already taken on pulsed molecular beam and mass spectrometry apparatus. Findings will be used to create new methods of protecting structural materials from extreme environmental conditions.

Formable High-Chrome Alloy Developed

A wrought alloy with high chromium content can be deformed at room temperatures with common metal-working techniques instead of being limited to casting methods. Named Matreloy, the metal was developed by Materials Research Corp. and found to be markedly more corrosion-resistant than the stainless steels and cobalt-chromium alloys. Ultimate tensile strengths as high as 375,000 psi have been demonstrated and there is a potential, depending on treatment, for higher strengths. Yield strengths range from 200,000 to 275,000 psi at room temperature and to 120,000 psi at 1,400°C.

Ceramics Substituted for Plastics

Close-tolerance, vitrified ceramic components can now be produced economically to any complex configuration, previously possible only with low-temperature phenolics and diallyl phthalates, at Ceram Corp. Tolerances of ±0.001 in. can be held without machining. The material Ceram can operate continuously up to 2,200°F. Leslie E. Roby, president, says the flow of the Ceram materials is superior to that of phenolics and diallyl phthalates. More data can be obtained from Ceram Corp., 5345 Timken Sq., La Mesa, Calif.

Plastic Ablatives Proven in 260-in. Firing

More than 9,000 lbs. of U.S. Polymeric FM-5131 silica cloth/phenolic tape used in the nozzle assembly of the Aerojet 260-in. solid met its predicted performance in the Feb. 23 test firing. The material is used as a thermal barrier to the outer shell, the exit cone lining and as a structural support for the insert during handling.

SPACE MEDICINE

Water Recovery Systems Pursued

Radiation Applications, Inc., working under a NASA contract, has been making progress on design of distillation systems for recovery of waste water in space cabins. The work will lead to construction of a flight-prototype demonstration model of a system using a reverse osmosis technique. Electrolytic pretreatment techniques also are being looked at, with an eye to applying pretreatment techniques on other means of water reclamation, such as electrodialysis.

Zero-G Calcium Loss Seen Minimal

Six to 12 months' exposure to weightlessness will not cause detrimental effects, either temporary or permanent, from loss of calcium, a physician from Douglas Aircraft Co. says. Extrapolating from two weeks of simulated weightlessness through bed rest, Dr. John M. Dick concluded that calcium loss that would be incurred by two weeks of weightlessness would be minimal. Measurements made included urine calcium levels before and after the test period and X-ray films of the oscalcis using the wedge technique.

ATS Project Seeks Practical Payoffs

Goddard satellite program to provide Earth pictures from synchronous altitude, data collections from moving platforms, multiple-access communications

by William S. Beller

WITHIN THE NEXT two years, Goddard Space Flight Center will launch five satellites designed to seek ways to exploit space as soon as possible.

The *Applications Technology Satellite (ATS)* project is the first major, multi-faceted attack NASA has made on the problem of getting an economic return on the country's investment in space exploration.

Goddard, as *ATS* program manager, intends to place four of the satellites into synchronous orbits since permanent stations in the sky appear to hold much promise for meteorological, communications, and even zoological work. The agency will launch the fifth satellite into a medium-altitude orbit of 6,000 miles. The satellites will be stabilized either by spinning or a gravity-gradient technique.

Emphasis on finding a way to use space in a practical fashion is reflected in the large number of technological "firsts" provided in the intrumentation of the *ATS* satellites, according to Robert J. Darcey, *ATS* project manager. These include:

—Optical pictures of Earth taken from synchronous altitude.

—A data collection system able to accept information from a very large number of platforms, some moving, such as free balloons, or others fixed on Earth, and relay the data to ground stations.

—A sophisticated, multiple-access communications system in a satellite.

—A ground-to-satellite-to-aircraft voice communication system.

—Broadcast-quality telecasts on a continuous basis between the United States and the Far East. The system can give a 50-db signal-noise ratio, exceeding CCIR standards.

—A satellite in synchronous orbit stabilized by gravity-gradient techniques.

Major contractors on the $101-million project are Hughes Aircraft Co., which is developing the spacecraft, and General Electric Co., developing the gravity-gradient stabilization system. *Atlas Agena D* boosters will be used.

Goddard plans to launch *ATS-B*, the first applications satellite, in December. It will have a synchronous orbit, weigh 1,550 lbs. and be spin-stabilized.

One of the most spectacular of the experiments calls for taking horizon-to-horizon pictures of Earth. If Dr. V. E. Suomi, meteorologist at the University of Wisconsin, succeeds in his experiment, he will have scored a prestige gain for the United States in addition to achieving technological benefits.

ATS-B will also carry an ion engine experiment, a VHF experiment involving communications between aircraft and ground terminals via the satellite, and a phased-array antenna to obtain a directional antenna.

Satellite view of Earth—The problem in trying to get a snapshot of Earth from *ATS-B* is to get an optical-quality picture from a satellite spinning at 100 rpm.

Suomi is using a Cassegrainian telescope fixed to the satellite to scan a thin swath of Earth from horizon to horizon every satellite revolution. The telescope has a 5-in.-dia. primary mirror and a 10-in. focal length.

The complete camera system is tilted in step with every satellite revolution so that succeeding scans of the Earth cut different swaths until a complete picture of 2,000 lines is accumulated. This takes 20 minutes. The light gathered by the telescope passes through a pinhole aperture one mil square to a photomultiplier tube, which measures the light's intensity.

The UHF transmitter on the satellite will send the picture information to a North American ground terminal for immediate processing. Then the information may be relayed to remote locations such as Australia and Japan through the VHF experiment aboard the satellite and accepted by APT (automatic picture transmission) ground stations.

The dynamic range of the Suomi camera is 40 db and the camera can resolve objects on Earth to within two nautical miles. However, on the *ATS-B* experiment, resolution on a real-time basis probably will be no better than between four and six nautical miles because this is the best the receiving electronic facsimile machine can furnish.

The satellite will have enough power for Earth photographs to be taken on a continuous basis. They will cover an area between 50 degrees north latitude and 50 degrees south. Wendell Sunderlin, assistant *ATS* project manager, said that experimenters can call for a real-time resolution of about two nautical miles if they are satisfied with looking at only a limited area of the Earth.

Suomi intends to process the picture signals on a digital machine, to preserve the two-nautical-mile resolution for the entire scanned surface of the Earth.

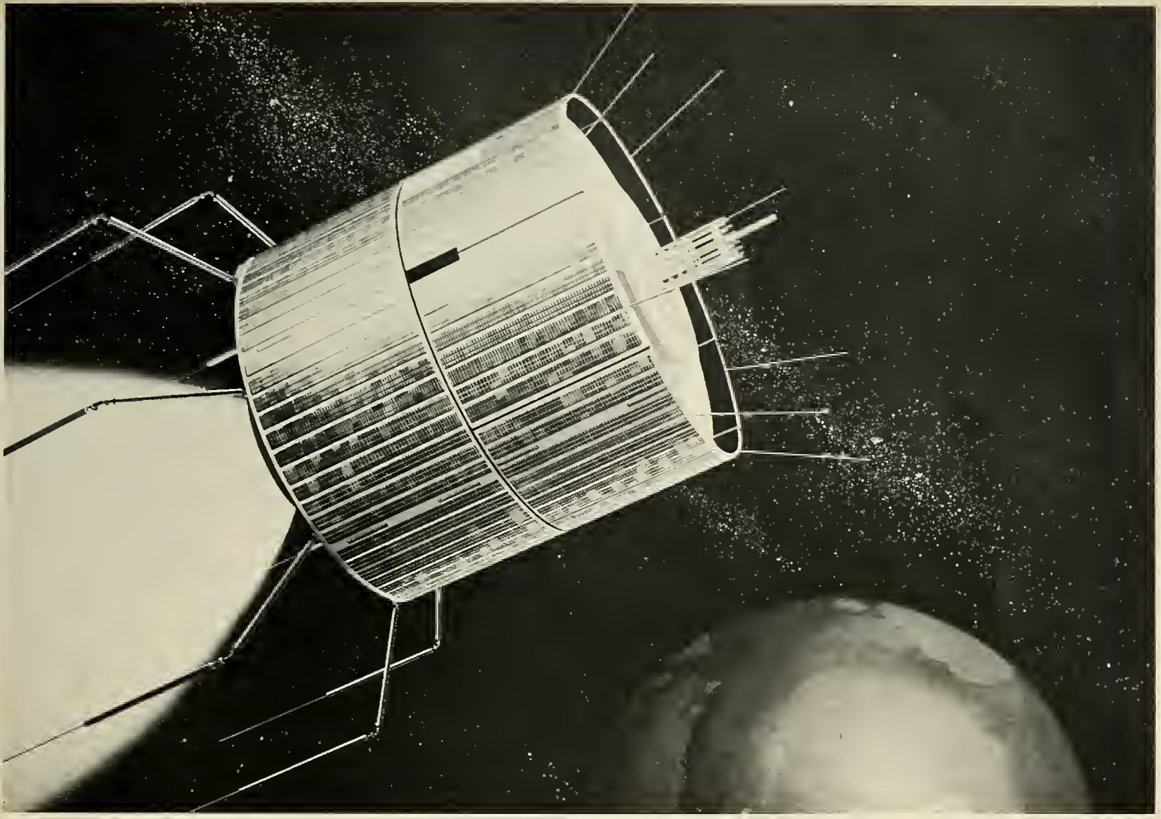
If the spacecraft's angle of nutation is more than 0.001 degree, the resulting pictures will be blurred. Darcey described a damper, made of a tube containing mercury, designed to take out the nutational energy simply through the sloshing of the liquid metal.

Ion-engine back-up—The *ATS-B* satellite will be used as a test bed for an ion attitude-control engine that will be used on the last two *ATS* satellites—*ATS-D* and *E*—if the engine is developed in time.

These two satellites, to be stabilized by gravity-gradient means, will require low-thrust engines for east/west stationkeeping. Goddard is considering an ion engine under development by Lewis Research Laboratories. Its thrust of 10^{-5} lbs. could be used to supplement or replace the presently planned subliming solid reaction engine.

In the *ATS-B*, the ion thrustor would be oriented to increase the spin rate of the satellite.

Communications experiments—All the applications satellites will investigate the transmission of television, voice, telegraph, digital data and facsimile. Two techniques will be used: 1) a frequency translation mode of operation where wideband signals are used to frequency-modulate the transmitted car rier and are relayed through the satellite to a ground receiver; and 2) a multi-



Artist's concept of Applications Technology Satellite B. Note phased-array antenna on right.

ple-access concept designed to permit a large number of ground stations to use the satellite simultaneously.

For multiple-access operation, single-sideband signals are transmitted from the ground stations to the satellite. At the satellite, the composite single-sideband signal consisting of the transmissions from all ground stations is converted to a phase-modulated signal for retransmission to the ground terminals.

The phased-array antenna system used on *ATS-B* produces an electronically controlled, conical beam at 4 gc, and is rotated at a speed equal to the spacecraft spin but in the opposite direction.

Gravity-gradient experiment—*ATS-A,* the second in the series, will be launched in mid-1967 into a medium-altitude orbit. The spacecraft will weigh 782 lbs. and have gravity-gradient stabilization.

The gravity-gradient experiment will provide a stable platform for the many experiments on *ATS-A,* will verify the mathematics previously used to prove gravity-gradient techniques, and, it is hoped, will show that gravity-gradient-stabilized spacecraft can have long lives.

The gravity-gradient stabilization system is composed of gravity-gradient booms, erection and scissoring mechanisms, passive dampers, and attitude sensors.

The orbital-configuration consists of four 150-ft. extendable booms mounted on the spacecraft in the form of an X. Their lengths can be controlled by extension mechanisms mounted within the spacecraft. A weight fixed to the end of each rod provides a suitable distribution of moments of inertia and ensures three-axis stabilization. A scissoring device which can change the acute angle between boom pairs is included in order to vary the moment-of-inertia ratios.

The passive dampers consist of a hysteresis type and an eddy-current type. Orientation of the spacecraft with respect to local vertical is found by the attitude sensor package which contains solar-aspect sensors, IR (Earth) sensors, antenna polarization (using the communications transmitting antenna), and a television camera in which attitude sensing is a secondary purpose.

Data collector—The OPLE—Omega Position Location Equipment experiment—will be the first attempt to see if a satellite would be able to collect a large mass of data from moving sources such as aircraft, balloons, buoys, or even appropriately outfitted land and air-breathing sea animals. Such data would then be relayed to Earth for meteorological, zoological, or other purposes.

OPLE will be on *ATS-C,* scheduled for a December, 1967, launch. It will be spin-stabilized in a synchronous orbit. Weight is as yet undetermined.

In the OPLE tests, the sources will be aircraft flying as aircraft, aircraft pretending they are balloons, ocean-plying ships, free buoys, and land-based stations to provide the experimental standards.

OPLE is based on a current Navy development called Omega that can be used to accurately locate each of these sources, and on a synchronous satellite to collect and relay to ground stations the data transmitted by the sources. Relayed data would also include the information needed by the ground stations to calculate the locations of the sources.

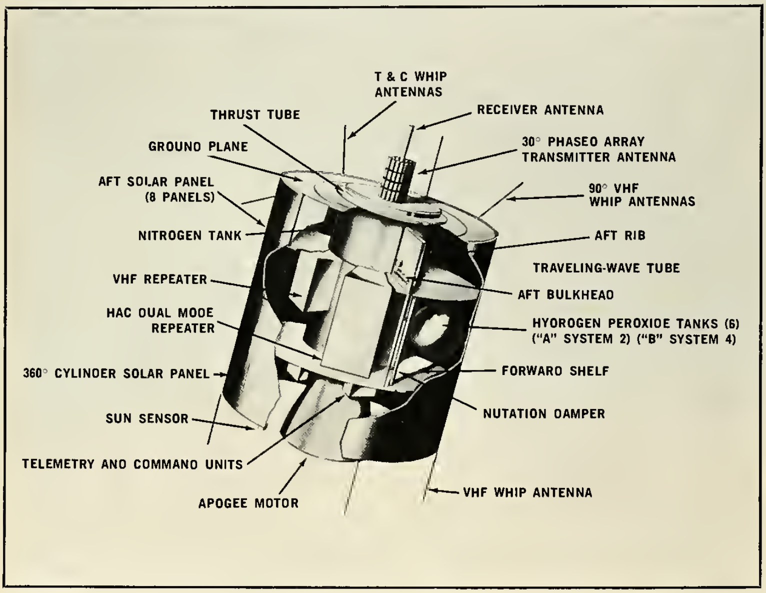
The Naval Electronics Laboratory, with the help of several other organizations including the Harvard Cruft Laboratory and the Naval Research Laboratory, developed the Omega system. It is based chiefly on a 10-year study of the characteristics of very-low-frequency (VLF) transmissions.

An extremely important finding was that the 10-kc region of the VLF spectrum has a very low attenuation rate and exhibits exceptional phase stability. These characteristics permit world-wide propagation of radio waves and allow phase measurements with an RMS variation of less than five microseconds.

Within the VLF frequency range, the radiated energy is propagated as a guided wave in the space between the Earth and the reflecting atmosphere. The signal can be used for position measurements up to a distance of at least 5,000 miles from the transmitter.

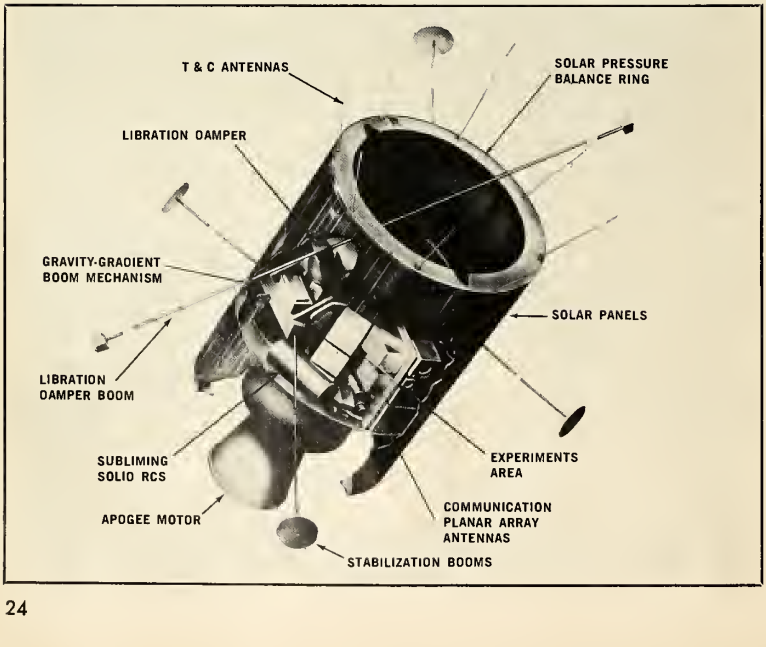
The experimental part of the Omega program is just about over. An Omega project office working under the Chief of Navy Material is busy setting up the first Omega arrangement of three VLF transmitting stations, expected to be ready early this year for fleet evaluation tests. In three years, the Navy is to have its operational network, made up of eight VLF transmitting stations radiating 10-kw each, with an average separation of about 5,000 n.mi. between stations.

In the first arrangement, as it applies to OPLE, the three VLF stations will send out signals of 10 kc, 11 kc, and 13 kc, respectively, for about one second. After a 0.2-sec. delay, the transmissions will be repeated, but not the same frequency from the same station, until all three stations have cycled the three VLF frequencies. The stations will then repeat their sequence of transmissions.


T & C WHIP ANTENNAS
THRUST TUBE
RECEIVER ANTENNA
GROUND PLANE
30° PHASED ARRAY TRANSMITTER ANTENNA
AFT SOLAR PANEL (8 PANELS)
90° VHF WHIP ANTENNAS
NITROGEN TANK
AFT RIB
TRAVELING-WAVE TUBE
VHF REPEATER
AFT BULKHEAD
HAC DUAL MODE REPEATER
HYDROGEN PEROXIDE TANKS (6) ("A" SYSTEM 2) ("B" SYSTEM 4)
360° CYLINDER SOLAR PANEL
FORWARD SHELF
SUN SENSOR
NUTATION DAMPER
TELEMETRY AND COMMAND UNITS
APOGEE MOTOR
VHF WHIP ANTENNA

Above, synchronous altitude spin-stabilized spacecraft.

Below, synchronous altitude gravity-gradient spacecraft.


T & C ANTENNAS
SOLAR PRESSURE BALANCE RING
LIBRATION DAMPER
GRAVITY-GRADIENT BOOM MECHANISM
SOLAR PANELS
LIBRATION DAMPER BOOM
SUBLIMING SOLID RCS
EXPERIMENTS AREA
APOGEE MOTOR
COMMUNICATION PLANAR ARRAY ANTENNAS
STABILIZATION BOOMS

A source with a suitable VLF receiver and other equipment to analyze and interpret the phase relationships between the received Omega signals will then be able to pinpoint its position on Earth.

For OPLE, a source will have only a VLF receiver and a VHF link to the satellite. Thus it will be left to the ground stations to get the Omega data by satellite relay. Sources such as balloons will not have to carry equipment better suited to ground installations, and yet OPLE experimenters will know the locations of all its sources.

While the sources transmit their position information, they will also send other data to the satellite through multiplexing equipment, perhaps from meteorological sensors.

The Omega technique applied to OPLE is fully described in the Goddard Space Flight Center publication, "Description of Experimental Omega Position Location Equipment (OPLE)," by Charles Laughlin, Gay Hilton, Roger Hollenbaugh and Richard Lavigne, published January, 1966.

Follow-on satellites—*ATS-D* and *-E*, scheduled for launch into synchronous orbits in 1968, will have gravity-gradient stabilization experiments aboard. They will also have an environmental measurement experiment (EME) package aboard, integrated by Westinghouse Electric Corp.

Among the proposals for the EME package (and Darcey stresses that none of these are yet approved) are a day-night camera involving an image orthicon, a millimeter-wave experiment at 16 gc, and an atomic clock experiment for a relativity test.

With respect to power and station-keeping, the *ATS* satellites can have an active life of about five years, Darcey estimates. There is enough power to run more than half the experiments full time, including the Suomi camera.

Goddard engineers and scientists working on the *ATS* experiments are very voluble about the economic payoffs that could result. One example: three synchronous satellites suitably placed in orbit could get continuous oceanographic data from hundreds of buoys drifting in ocean streams, meteorological data at all levels of the atmosphere from balloons, and cloud-cover data from the on-board cameras. These would be the inputs needed for long-range weather forecasting. ■

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Rolls Royce Materials Work Stresses Filament Composites

by John F. Judge

DERBY, ENGLAND—Rolls Royce experts expect fiber-reinforced metals to reach the commercial stage within five years if the present level of growth and interest is maintained.

The firm, known for its "perfect" motor cars, and jet engines, is betting heavily on composites and has introduced glass-reinforced plastics as an engineering material in the RB 162 series of lift jet engines for VTOL applications.

The advanced research department of the Aero Engine division has been actively investigating fiber-reinforced metals for years. A large body of data and understanding of such composites has been created.

The greatest emphasis has been on filaments. Rolls experts feel strongly that filaments will contribute to engineering applications in metal composites much sooner than will whisker reinforcements.

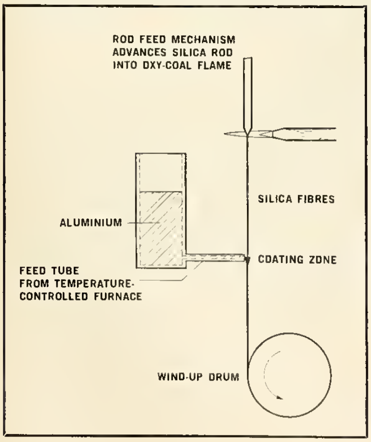
All current programs at Rolls in composites are considered proprietary but the firm is working with all available fiber materials and metal matrices except boron. There is no boron work only because it is not yet available in England.

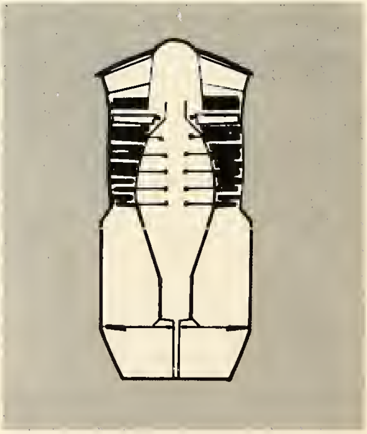
Aluminum-glass combination—There is a firm belief that the proper approach to composites is through a complete familarity with both the components—the fiber and the matrix. Early work at Rolls focused on the glass-fiber aluminum family. Reasons for the choice were not tied to development of a specific engineering material, even though it now appears that Rolls will initiate composite applications with this combination. The aluminum-and-glass-fiber family is best described as an experimental model.

J. G. Morley of the advanced research group says that composites of aluminum reinforced with silica fibers can be fabricated in experimental quantities and control can be exercised over a large number of the parameters that must be considered if an understanding of the general characteristics of fiber-reinforced metals is to be obtained. Rolls researchers have made a respectable dent in this problem.

The standard fabrication approach to lab samples at Rolls is to first coat the fibers with aluminum and then hot-press the coated fibers together to form the composite. These samples have been under every kind of engineering analysis at Rolls for some time.

Metal coating of filaments in the lab used Arridge technique at left. Glass plastic parts of the RB-162 are shown as black sections in the diagram at right.


ROD FEED MECHANISM ADVANCES SILICA ROD INTO OXY-COAL FLAME
SILICA FIBRES
ALUMINIUM
COATING ZONE
FEED TUBE FROM TEMPERATURE-CONTROLLED FURNACE
WIND-UP DRUM



The adverse chemical reactions between silica and aluminum have been controlled at Rolls—first by bismuth additives and currently by eliminating additives and concentrating on process cleanliness.

Coating procedure—The coating process, developed by R. G. C. Arridge of Rolls, starts with fused silica fibers drawn down from a 4-mm transparent silica rod heated in a gas flame.

The rod is fed continuously into the oxy-coal gas flame and a thin fiber is drawn off by a rotating drum. The relative speeds of the drum and rod-feed determine the mean fiber diameter. At a suitable distance from the flame, the fiber is passed through a bead of molten metal held in a specially designed nozzle and maintained by the flow from a melt pot. The fiber is completely coated with metal before being wound on the drum.

There are several control points necessary in the system. For instance, if the melt is too cold, it will freeze and break the fiber; if too hot, the coating is patchy and incomplete. Too high a melt temperature almost always results in a weakened fiber.

The technique allows for the possibility of varying the interfiber distances by controlling fiber diameters and the thickness of the aluminum coating. The uniformity of the aluminum layer leads to a uniform distribution of the fibers within the composite.

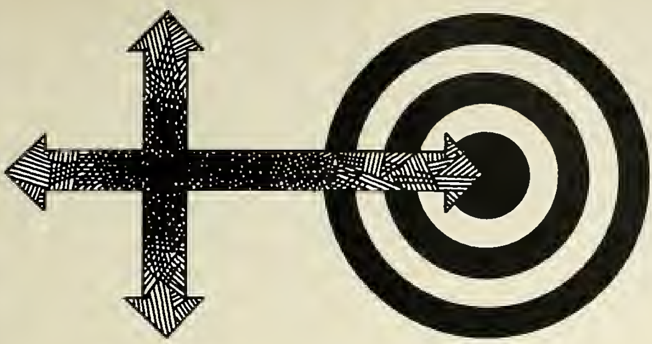
The fabrication technique makes it possible to produce complex shapes to final size in one pressing operation. Rolls researchers have found that the samples produced have much improved fatigue characteristics compared with the matrix.

Morley says the area of greatest ignorance with such composites is fatigue. Rolls has been working in this field for some time and the effort is still in progress. Fatigue is a complex problem because the brittle fibers probably do not suffer from oscillating load fatigue as do metals but static fatigue such as that found in glasses may be encountered

There is little knowledge about the fatigue behavior of metals when they are used as matrices or of the effect between the fiber-matrix interface. Fatigue tests—as well as investigations to determine creep resistance, toughness, damping capacity and wear resistance of the aluminum composite—have been in progress for more than a year.

The firm is extremely hesitant to describe recent efforts in the development of fiber-reinforced composites. But a prime example of how the composite material research is being fed into production areas is in the RB 162 lift-jet engine.

Conventional processing—Actual



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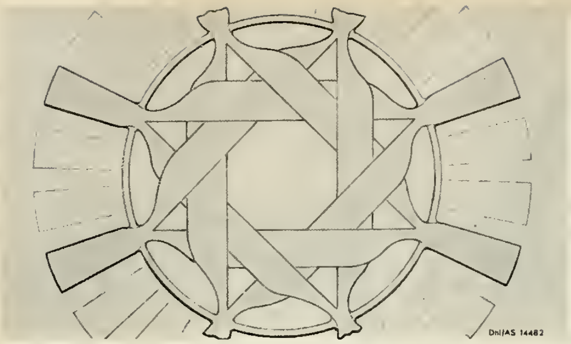

Integral blade and disc combination concept represents the maximum efficient use of fiber reinforcement in compressor stages.

processing methods in use at Rolls are the standard ones used throughout the U.S. But the firm has development shapes and components in various stages of pilot production in the same shop that turns out the RB 162 components. The lift-jet plastic line experience will probably be a considerable asset as other composite formulations and combinations move out of research.

Almost the entire front half of the RB 162 lift-jet engine consists of glass-reinforced plastic. Most of the cool parts are reinforced-plastic, including five of the six stages of rotor blading and all the stators. A 5,000-lb.-thrust growth version of this lift-jet is in being at Rolls.

The only application of this engine is in the prototype GAM Dassault Mirage III-V. Eight lift jets provide the total lifting thrust. The first flight of a second aircraft, the Dornier DO31, is scheduled for the near future.

The Dornier craft is a tactical German V/STOL transport using four RB 162 units in two pods.

Composite peculiarities—The glass-fiber composite used has about the same density as magnesium and is instrumental in reducing both the weight and cost of the lift-jet. Rolls experts are fully aware that the introduction of composites is not simply a case of materials substitution. Their tensile strengths, crushing strengths and Young's moduli differ from those associated with conventional aircraft engine metals.

In addition, the build-up of composites can be engineered to reach maximum strengths in the direction of principal stresses—all factors well known to U.S. firms in the composite areas.

A. A. Lombard, director of engineering, Aero Engine Div., says the successful use of composites involves a different kind of engineering and one which has to be studied and understood.

For example, Lombard points to the specially designed dovetail root in the glass-reinforced compressor blades on the RB 162. The root has a wedge-shaped metal insert bonded into the blade. The reinforcement fibers do not all run spanwise along the foil. Certain fibers are angled to obtain the required torsional deflections and to adjust the torsional and lateral vibration frequencies.

Lombard says that in addition to this natural "tuning" ability of composites to adjust their frequencies, the materials have good inherent damping capacities and excellent fatigue properties. Not a single glass/plastic compressor blade broke during the entire development period of the RB 162 engine.

Winding too costly—Rolls has avoided filament winding as a fabrication technique with glass-fiber composites. The firm prefers hand lay-up, contact molding, die molding and hot compression methods rather than filament winding because of the high cost of winding apparatus.

Both production and experimental shapes are handled in the same Rolls facility. The major problem is the same as that with many U.S. shops—adequate non-destructive test procedures. Rolls is looking at certain infrared techniques and keeps abreast of U.S. developments in this testing field.

In jet engine development, joining of the vanes to the discs is still the major problem. Rolls has some concepts involving integral blade-and-disc combinations using fiber reinforcement. Here the fibers feed directly from the blades into the discs, across them and into blades on the opposite side. The concept, if achieved, results in the most efficient possible use of the material with an assembly of minimum weight.

Lombard says the lift-jet experience shows that composites can be introduced into propulsion engines with significant effects on weights and cost. Materials currently available and under development are suitable for the cooler components such as the by-pass duct, the complete low-pressure compressor, the front bearing housing assembly, the intermediate casing, the high-pressure compressor casing and about half the high-pressure compressor rotor and stator blades. ■

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AF Probes Fires in 100% Oxygen

ARC study shows many materials thought to be non-combustible burn in space-cabin atmosphere; usual retardants ineffective

A STUDY of combustibility in 100% oxygen at 5 psi has disclosed that many materials not considered to be combustible burn after prolonged exposure, and normal fire-retardant treatments do not appear to be effective.

The conclusions are part of a report released by the Air Force School of Aerospace Medicine on a contract performed by the advanced technology division of Atlantic Research Corp. Dr. Hans Clamann, a pioneer in the study of spacecraft atmospheres as well as other aspects of space medicine, and Capt. John Hargreaves of SAM directed the work.

The study was precipitated by several fires that occurred during space cabin simulations including those at the School of Aerospace Medicine and at a Navy experiment at Point Mugu, Calif. These fires spread rapidly, were extremely intense and difficult to smother by normal means.

While there has been a great deal of research on combustion and fire hazards, little existed that was directly applicable to spacecraft work, except for limited tests of selected fabrics and materials.

The Atlantic Research test was aimed at determining the effect of prolonged exposure of spacecraft materials to the 100% oxgyen, 258-mm Hg atmosphere. Materials were pre-tested in air, then in 100% oxygen at 258-mm Hg, and then after 30 days' exposure to this atmosphere. The research group also sought to obtain a theoretic understanding of combustion phenomena under these conditions, for help in planning future experiments and for extrapolation to other atmospheres.

Testing procedure—A cylindrical tank 14.5 in. in diameter by 33 in. long with a volume of 3.2 cu. ft. was used as a combustion chamber for the test. This was hooked to a source of 100% oxygen, providing enough oxygen in the chamber so that the samples would burn without unduly affecting the pressure or temperature within the chamber.

Samples that had been stored in the oxygen atmosphere for 30 days were passed through an airlock to avoid exposing them to any other atmosphere or pressure.

The material samples were ignited with a wire much like they might be by an overheated electrical wire, in those tests aimed at determining flame spread rates. In ignitability tests, a special ignition source was used that could be controlled to precise specifications.

The Atlantic Research group, headed by Dr. Clayton Huggett, selected two groups of materials for testing. The first, standard reference materials, included butyl rubber, canvas duck, cellulose acetate, Kel-F, natural and neoprene rubber, Nylon 101, Plexiglas, polypropylene, polystryrene, polyvinyl choride, silicone rubber, Teflon and Viton A.

These covered a wide range of com-

Possible Lunar 'Landmark' for Astronauts

This 15-ft.-dia. inflatable balloon may play an important role in man's exploration of the Moon. Designed and fabricated by Goodyear Aerospace Corp., the device is made to be placed on the lunar surface, from which it would reflect the Sun's rays, and thus serve as a "landmark" on the Moon for astronauts. Two of the aluminum spheres have been built under contract to NASA's Langley Research Center. They would be carried to the Moon by unmanned spacecraft, then released and inflated automatically, to serve as lunar landing "beacons."

positions and physical properties, and were materials for which data are available for combustion under normal atmosphere conditions.

The second group was provided by SAM, and provided a range of materials commonly used in space-cabin construction. Ranging from aluminized Mylar tape, electrical insulating resin, foam insulation and cushion materials, paint samples and various oils and grease to Tygon tubing, they are materials of indefinite construction and complex structure and composition.

Where possible, specimens ½ in. wide and 3 in. long were clamped in holders inside the combustion chamber, which was filled with oxygen and evacuated to the 258-mm Hg pressure.

The materials were ignited, and photographs were taken by motion picture camera through viewports in the chamber. Three or more duplicate tests were made for each material.

Results—The researchers found that slightly less energy was required to ignite most of the samples in the oxygen atmosphere than for ignition in air. However, one material presenting a large differential was asbestos tape, which took only one-third the energy needed to ignite it in oxygen as in air.

Although the flame spread rates were found to be greatly influenced by the shape and construction of the sample, the Atlantic Research group found that flame spread rates were greater by one to three orders of magnitude in the oxygen atmosphere than in air.

Some materials that do not burn in air burn vigorously in oxygen. These included Kel-F, neoprene rubber, Nylon 101, polyvinyl chloride, silicone rubber, Teflon and Viton A.

However, the samples that had been exposed to the oxygen atmosphere in capsules for one month did not show any gross difference in flame spread rate than those exposed to oxygen at 258-mm Hg for the first time.

This led the researchers to conclude that long exposure to the oxygen-enriched atmosphere does not significantly increase the fire hazard in spacecraft and spacecraft simulators, a conclusion which the group said was supported by experimental data and theoretic considerations.

The behavior of fires in some of the space cabin simulator experiments had led observers to suspect that there might be a "soaking" effect of oxygen over a long period of time. On at least one occasion it appeared that everything used to try to smother the fire—a towel, a man's hand—itself ignited.

The Atlantic Research group explains, however, that equilibrium is rapidly established between gaseous oxygen in the atmosphere and oxygen adsorbed on the surface or dissolved in the test specimen, and no further change should be expected.

On the other hand, they point out, slow chemical reaction will occur with some materials—unsaturated organic materials such as rubber—to form peroxides and other reactive chemical species. If these accumulated over a period of time, they might have a significant effect on ignitability and combustibility.

While rate of formation of such products depends on temperature and the partial pressure of oxygen, little difference should exist between the 30-day oxygen exposure at 258-mm Hg and that of the same material exposed to air for long periods under normal conditions.

Recommendations—The group also found that the rate of flame spread over a horizontal surface and downward on a vertical surface did not vary much in magnitude. Thus, since apparently not governed by convection, these rates should also apply to the zero-g environment of spaceflight, they point out.

The pronounced effect of the kind of surface, however, led to the recommendation that spacecraft interior design should minimize or avoid the use of rough or porous surfaces, sharp edges and adjacent combustible surfaces. ■

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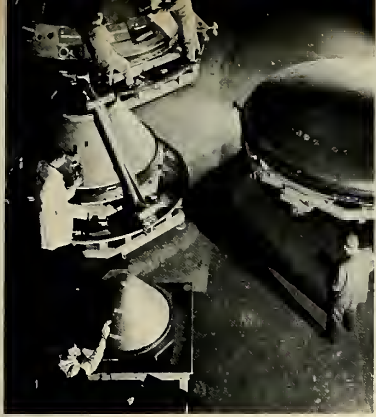
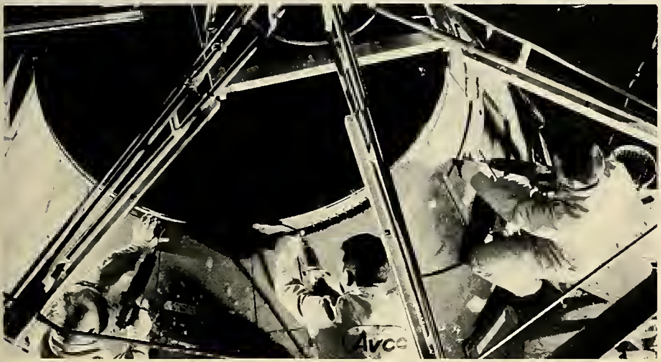
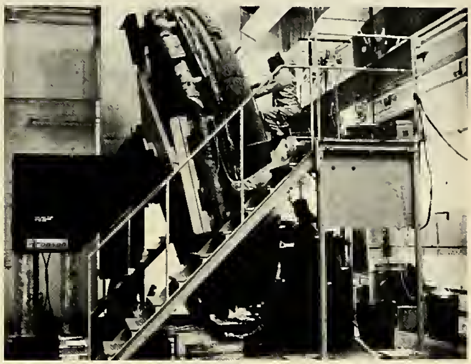
CENTRAL INTELLIGENCE AGENCY



Early Data Indicate Success For Apollo Re-entry System





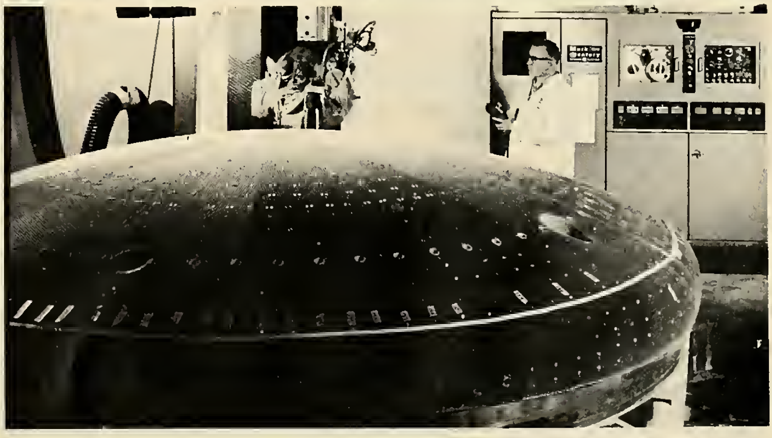
Rough data returns from the *Saturn/Apollo* sub-orbital test Feb. 26 indicate the Avco Corp. re-entry thermal protection system functioned perfectly.

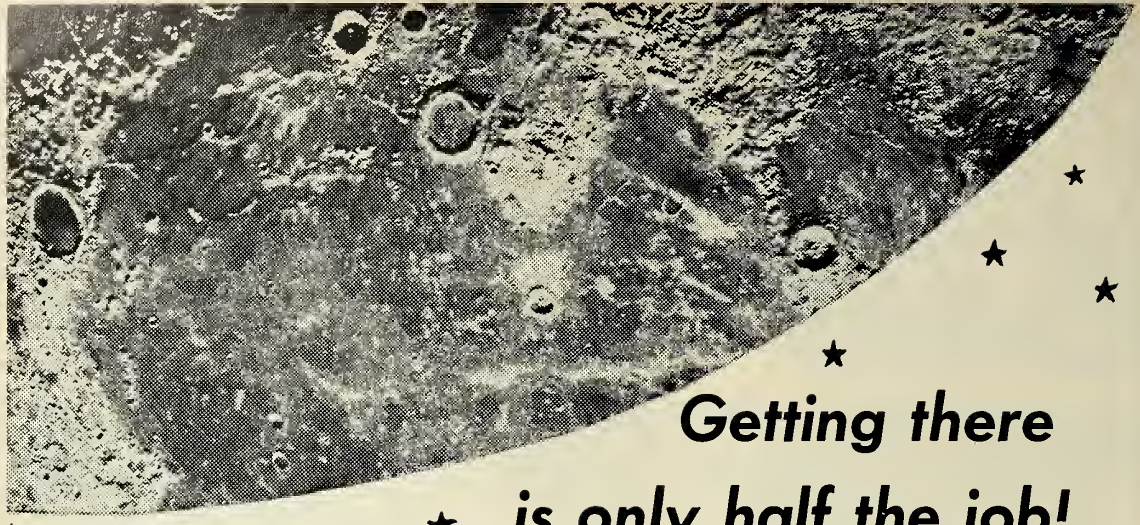
The prime shield material is a filled phenolic epoxy resin injected into honeycomb reinforcement at the firm's Advanced Research and Development Div.

The *Apollo* assembly area is shown at top with all four sections of the Command Module. Avco technicians are injecting the heat-shield material around the crew compartment above. The aft section is mounted in a special rig so that material injection can be accomplished simultaneously across the entire surface (above right and right).

After the heat-shield material has been applied, the blunt aft section of the Command Module is machined to exact specifications on a large, numerically-controlled vertical turret lath (bottom). The aft insulation is contoured to varying thicknesses across the re-entering surface.

All cells are X-rayed to check correct fill and density in each of the 370,000 apertures. The material will handle peak re-entry temperatures of 5,500°F yet must retain its integrity in the vacuum of space and after exposures to temperatures down to —150°F in the vicinity of the Moon. The operations shown are in the *Apollo* production line at Avco.





Getting there is only half the job!

The severest, most crucial, and most dangerous lap of the voyage to the Moon will be the final stages. The problem of re-entry is one of the most forbidding of the whole manned space program. The ablative heat shield which will protect the three Apollo astronauts from the inferno of re-entry is only one of the latest developments underway at Avco/RAD. Other fascinating projects are military space systems, scientific satellites and interplanetary probes

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The Industry Week

Mergers and Acquisitions

Astrosystems International, Inc., Fairfield, N.J., has purchased the assets of Frost Electronics Corp., Rockaway, N.J. Frost, producer of photoelectric controls, will be operated as a wholly owned subsidiary of Astrosystems. Astrosystems is an R&D firm specializing in photometrics. . . . *Computer Sciences Corp., El Segundo, Calif., has acquired Alfred Politz Research, Inc., New York City market research firm. The purchase is another step toward CSC's development of a total capability in the information sciences, a company spokesman said.* . . . Chas. Pfizer & Co. Inc., New York City, plans to purchase the assets and business of Space Age Materials Corp., Woodside, N.J. Purchase price is 23,992 shares of Pfizer common stock. Space Age Materials is a research-oriented firm specializing in high-temperature materials. Two SAMCO subsidiaries—Pyrogenics, Inc., and Pax Electronics Co., Inc., —are included in the acquisition. The firm will be operated in association with Pfizer's Minerals, Pigments and Metals Div. . . . *Emerson Electric Co., St. Louis, Mo., and Ridge Tool Co., Elyria, Ohio, are considering a merger of Ridge into Emerson Electric. The plan has been approved by directors of both firms and is now subject to stockholder approval. Under the plan, Ridge would be operated as a separate division of Emerson.* . . . Willamette Valley Co., Eugene, Ore., has purchased Harrington Enterprises Corp., also of Eugene. Harrington designs and manufactures environmental chambers for the life sciences.

International

Georator Corp., Manassas, Va., has obtained rights to market environmental chambers designed by Dr. Ing. Rolf Schroedter, Bad Godesburg, Germany, throughout the U.S. and other English-speaking countries. The chambers are designed for research on effects of high altitudes on humans.

New Activities

Cober Electronics, Inc., has been established in Stamford, Conn., by Sandford Jacobson and Bernard Krieger. The firm will produce high-voltage power supplies, pulse modulators, test equipment and heavy electronics transmitters. . . . *Anaconda Astrodata Co. has been formed in Anaheim, Calif., as a joint venture of Anaconda Wire and Cable Co. and Astrodata, Inc. The firm will manufacture and market electronic communications equipment. Initial operation will be at Astrodata's main plant in Anaheim.* . . . The National Council of Technical Service Industries has been incorporated in Washington, D.C. The industry association is designed to promote use of private industry resources to support essential federal government activities. Edward R. Wagner has been named executive director of the non-profit educational organization. . . . *Atlantic Research Corp., Alexandria, Va., has established an Ordnance Div. The new division will incorporate several existing company operations supporting the nation's tactical warfare effort.* . . . Micro Systems, Inc., Pasadena, Calif., has formed a bio-medical instrumentation group. Eph Konigsberg has been named product manager.

Facility Expansion

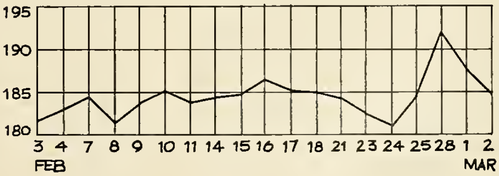
Motorola, Inc.'s Military Electronics Div., Scottsdale, Ariz., is increasing its plant facilities by nearly 50%. Additions totaling 145,000 sq. ft. will be added to the plant. The construction is expected to be completed by Nov. 1. . . . *Electro Oceanics, a division of Winsco Instruments and Controls Co., has moved to a new location at 2000 Colorado Blvd., Santa Monica, Calif. The firm, formerly located in Encinitas, Calif., manufactures underwater electric systems.* . . . ITT Industrial Laboratories has leased additional space for its electronics research and product development division in Fort Wayne, Ind.

Industry Representatives

Babcock Relays, a division of Babcock Electronic Corp., Costa Mesa, Calif., has appointed Kitchen & Kutchen, Inc., sales representative in the New England area. . . . *Bendix Corp's Filter Div., Madison Heights, Mich., has named S. F. Foster Co., Inc., Pompey, N.Y., to distribute the firm's fluid filtration devices in northern New York. CTR, Inc., Hurst, Tex., has been named Midwest sales representative and distributor.*

Missile/Space Stock Index

The Missile/Space Weighted Stock Index led a stock market surge on Monday, Feb. 28, leaping almost 8 points to 192, the first time it has surpassed the 190 mark. However, while the rest of the market took a plunge the following day, the Index receded only to 187.85, still one of the highest points of the year. A number of financial analyses by various investment research firms recommending defense/space stocks, passage of the supplemental defense bill in the Congress, and favorable financial reports have stimulated the Index activity in recent days. The Index reflects the action of 19 companies chosen as bellwethers of the defense and space industry. The figure 100 represents their stock prices on Dec. 31, 1964. Adjustments have been made for splits.



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

New Radar System To Aid ECM Design

Radar Target Measuring System, with Westinghouse as prime and Rohr building antenna, boasts extremely high data rate

by Rex Pay

WHITE SANDS MISSILE RANGE, N.M. —A Radar Target Measuring System due to go operational here within two months will collect accurate radar signatures of Army missiles for improved electronic countermeasures design.

The system will reveal what a missile looks like to an enemy radar, so that the requirements for an on-board electronic disguise can be better understood.

A typical countermeasures system carried in such missiles would receive an enemy radar pulse, amplify it and return it with an added delay. The returned pulse at the enemy radar would then appear as a large target in a position differing from that of the incoming missile.

The new RTMS will show how much power must be put into the deception pulse in order to hide the skin echo of the missile.

High data rate—Outstanding feature of the new radar system is its high data rate—one million data words per minute. The receiving system employs an 85-ft. dish antenna with automatic tracking. It takes 18 different radar cross-section measurements on every returned pulse.

The radar system derives in real time the radar cross-section matrix of the target, recording 18 different parameters per pulse repetition. Both straight pulse and chirped pulse radar modes are available.

Apart from the high data rate, the radar system has to be able to cope with a wide range of targets, from 0.01 sq. m. up to the area of military aircraft. With this wide dynamic range goes the requirement for high linearity in the receiver. Previously, wide dynamic range has been achieved by use of automatic gain control, but this has necessitated a non-linear system with very cumbersome calibration.

A mesh surface is now used for the antenna, and operation at three point-frequencies in the 150-500 mc spectrum is currently planned.

Prime contractor for the RTMS is Westinghouse, with Rohr Corp. providing the antenna structure.

The antenna is being installed for the Missile Electronic Warfare Technical Area, commanded by Maj. David J. Klora. It is located close to Highway 82, opposite the *Nike-X* Multifunction Array Radar, in the middle of the Southern end of the range.

One of three elements—MEWTA is responsible to the Electronic Warfare Laboratory of the Army Electronics Command at Fort Monmouth, N.J. As such, it is one of the three Electronics Command elements at WSMR, which form a new organizational structure replacing the Electronics Research and Development Activity (ERDA).

The other elements are the Atmospheric Sciences Office, reporting to the Atmospheric Sciences Laboratory at Fort Monmouth, and ERDA White Sands, which fulfills staff functions and reports directly to Electronics Command.

RTMS "is an expensive investment at White Sands and it will be used to its fullest operational extent," said Klora. Since, however, the system is not yet operational, it is unknown how much it can be applied to non-METWA programs. It may be used for Air Force programs such as *Athena.*

James W. Jones, chief of the ECM Systems Office, who is currently guiding development of the RTMS, pointed out that the system is primarily a data-gathering instrument and is not intended for range support. It is not designed as ballistic measuring radar, but can provide enough ballistic information to enable the RF data collected to be correlated with the true ballistics of the target, as measured by the Range's FPS-16 radars.

Jones said the information picked up by the radar antenna is processed and digitized on-site, and recorded on a seven-channel tape recorder. Data words are maintained at a uniform six bits in length, although the recorded data may not always occupy the whole word length. Antenna beamwidth varies from 1.5 deg. to 5 deg. over the frequency range. Transmitter tubes are standard 0.5-megawatt types.

No end product—Klora pointed out to M/R that MEWTA is the sole Army installation involved specifically in conducting electronic warfare studies of Army missile systems. "Our aim is to provide a system that is reliable and that will not be obsolete by the time it is fielded," he explained. The unit currently has five officers, 59 enlisted personnel and 134 civilian employees assigned to it.

Although MEWTA produces some unique pieces of equipment, it does not provide an end product for use in the field. A large part of its work is in investigating the vulnerability of missile systems to electronic countermeasures. It has been involved, for example, with the *SAM-D* missile system since the original concept, and also with the *Nike-Zeus* and *Nike-X* system.

The unit makes theoretical and mathematical analyses of a proposed system and then runs laboratory tests on hardware as it become available. For such things as a missile guidance package or a radar receiver amplifier MEWTA will check its responses to the correct signals and to superimposed interference.

Later, as the complete system becomes available, the Range will operate it and MEWTA will measure its vulnerability as a system.

Although MEWTA relies heavily on WSMR for range suport, it has its own unique equipment including two aircraft that are maintained and operated by the Air Force at Holloman AFB, N.M. These, a C-130 and a C-131, both extensively modified, provide a flying test bed for various types of equipment. They are heavily instrumented and various forms of passive and active electronic countermeasures can be installed to suit different missions.

Aid to designers—Vulnerability

studies tend to make MEWTA unpopular, but the results it obtains are not solely in the form of criticism; it also provides useful inputs to the design process. "The field of electronic warfare has been an awfully difficult row to hoe since World War II in the area of acceptance," commented Jack W. Jones, Chief of Anti-Missile Missile Development. "But our sole interest in life is to field a good weapon."

MEWTA enters into the missile cycle at the development level, giving advice during design and providing data from experiments on circuits and subsystems to the Army Missile Command and to the specific organization developing the missile.

The unit also acts as a storehouse of information on potential countermeasures techniques and carries out research into them. This is essentially applied research, carried out by the working staff as part of its normal program. They investigate new jam-resistant radar techniques, for example, even if these do not have an application at present.

Missile-borne jammer—One specific development of MEWTA in the ECM field is the first Army missile-borne jammer. This has been produced as a basic feasibility model as part of the unit's role as an investigator of experimental systems. The outcome of this investigation is a technical report that tells missile developers that the jammer will improve the performance of a system to a specified degree. "We have never got to the point of saying this should go on a missile," said James Jones.

The feasibility model of the missile-borne jammer was built under contract by Philco's Aeronutronic division. Initial experiments were on captive aircraft flights. Later the jammer was flown on small unguided ballistic rockets, typically *Apaches, Nike-Apaches*, or *Nike-Cajuns*. This jammer may go into the production prototype stage at Aeronutronic.

At present MEWTA is continuing this line of development, aiming at higher outputs and improved transmitter characteristics.

MEWTA's role in testing weapon systems for their ECM characteristics is not restricted to radio-frequency studies. Parallelling the RTMS development is another program to measure the characteristics of targets across the spectrum from ultraviolet, through the visible, into the far infrared. Used for this task are two mobile tracking systems that carry passive measuring instruments. One is an M33 fire-control radar, modified for passive tracking. The other is a modified *Nike-Ajax* radar which has been altered in the same way. ■

Isotope Radiation Used To Measure Ablation Changes

THE DYNAMIC PHYSICAL and chemical changes occurring in the ablation of thermal protection materials can be measured by using gamma radiation from isotopes during flight.

A technique being developed by NASA's Langley Research Center and Emerson Electric Co. is proving feasible in the continuous measurement of both surface recession and pyrolysis through radioisotopes embedded in the ablative material.

The basic method consists of selecting two isotopes so that the depletion rate of one will correspond to the recession of the ablating surface and the depletion of the other is a measure of the ablative material decomposition.

A detector system capable of differentiating between energy levels monitors radiation from each of the two isotopes. Detected counts are integrated and supplied as outputs of the system in a form compatible with spacecraft telemetry.

The Langley setup, described at the recent symposium on Radioisotope Applications in Aerospace by Peter J. LeBel of the NASA center, consists of bonding 0.25-in. plugs of ablator impregnated with approximately 20 microcuries of each isotope (In^{114m}—pyrolysis measurement, and $Zr\text{-}Nb^{95}$—surface recession measurement), into 1-in.-dia. plugs of the same material. Heating sources for specimen runs and the calibration tests were oxygen-acetylene torches.

LeBel says that while the isotopes chosen worked within the confines of the experiment, it would be desirable to select isotopes which do not possess some of the characteristics of the existing sources—such as the indium energy peak at 0.72 MeV within the zirconium-niobium window.

Operational problems—Before such an instrumentation system can be effectively used in any flight vehicle, several flight system requirements must be met.

Choice of isotopes for a flight system is limited by geometry of the payload to the extent that the radiation must pass through both the ablative material and the vehicle structure with a minimum of absorption.

Since the source would also have to be installed long before launch, relatively short-lived isotopes cannot be used. A minimum of activity is another guideline to reduce gamma exposure of personnel during launch preparations.

Since the detector assembly would be mounted near the ablative heat shield, where space is generally at a premium, it must be small. In addition, the unit has to be extremely rugged, because a payload launched on a small solid rocket in an Earth re-entry flight test may experience accelerations up to 150 g and shocks to 250 g for 15 milliseconds.

LeBel says a scintillation crystal photomultiplier detector assembly rugged enough to survive this environment might occupy a volume of as much as 25 cu. in. He says that it is hoped that new detectors will be small, rugged and efficient.

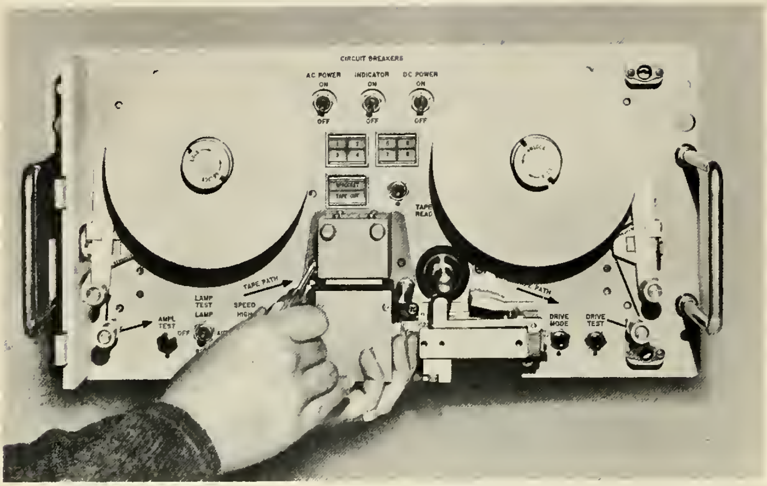
One final requirement is that the system go through the necessary flight qualification tests. Since a plasma-arc facility with the ability to handle millicurie levels of activity is not available, the Langley experiments used the oxy-acetylene approach.

The system performance should be evaluated in an environment more representative of re-entry heating.

Simultaneous measurements—The Langley experiments have indicated it is possible to measure dynamically the ablation characteristics of thermal protective materials in such a way that two diverse measurements are achieved simultaneously in exactly the same location on the shield. The approach taken is also independent of any effect of the ionized plasma normally surrounding a re-entering space vehicle.

The technique permits a straightforward determination of char thickness at the point of measurement. In addition, the radioisotope method will measure pyrolysis recession in ablation materials which are electrically conducting in the virgin state.

The ablative materials chosen in the experiments were phenolic nylon, a low-density composite of nylon powder and phenolic resin; and phenolic graphite, a high-density mixture of phenolic resin and graphite fibers. ■



New Product of the Week: Perforated Tape Reader

A militarized perforated tape reader that provides operation from —25° to 135° F has been announced by Potter Instrument Co., Inc.

Model PT-5000 features complete interchangeability of adjustment-free assemblies and built-in diagnostic test exercises and indicators. Self-contained manual test panel and indicators allow manual operation or malfunction isolation without test equipment.

MTBF is 3,000 hours. The unit uses three types of printed circuit board modules—sprocket data channel, start/stop control, test-lamp driver.

Environmental conditions are rated as follows: shock: 25 g's for 40 ms, vertical axis; 15 g's for 40 ms in remaining axes. Vibration: 2 to 20 cps at 2 g's; 20 to 200 cps at 4 g's; 200 to 500 cps at 2.5 g's. Humidity: 0 to 95% relative. RFI: MIL-I-6181, MIL-E-6051C. Power: 28v dc ± 4v at 3 amps; 12v dc ±5% at 2.6 amps; —12v ±5% at 0.280 amps 115v ac 400 Hz at 1.1 amps, 3 phase.

Circle No. 151 on Subscriber Service Card

Signal Generator

A wide-range signal generator for use in studying communications and broadcasting equipment has been announced by Rohde & Schwarz Sales Co., Inc.

Type SMAR combines the features of a low-frequency generator, high-frequency generator, high-power generator and mircrovolt generator and can function as any one of these.

The instrument covers 29 Hz to 31 mHz in six steps. Frequency accuracy is 1 (10^{-4}) when standardized against the internal crystal oscillator. It can be synchronized to an external frequency synthesizer of frequency standard. Pulling range for locked control is 0.5%/v of the applied synchronized signal. A range of attentuation values from 0.1 to 300 µv in 8 steps and from 1 mv to 10v in 9 steps can be obtained.

The unit has switchable output impedances of 50, 60, 75, 150 and 600 ohms. Frequency response varies less than 0.15 db from 30 kHz to 20 mHz and less than 0.3 db from 20 mHz to 31 mHz. Harmonic distortion is less than 5% for 10-v output and less than 2% for all attenuated outputs.

Circle No. 152 on Subscriber Service Card

Six-Digit Voltmeter

Hewlett-Packard has introduced a standard/differential voltmeter with d-c voltage accuracy specified at 0.002%.

Model 740B has six digital places, available in discrete steps to 1-ppm resolution including incorporation of a digitally calibrated standard vernier. The unit fully complies with MIL 6181D specifications.

As a d-c standard source, the voltmeter produces output levels from 0 to 1,000v. Under standard measuring conditions, accuracy is ± 0.002% of setting + 0.0002% of range. Accuracy remains ± 0.005% of setting + 0.0002% of range with temperature variations from 15° to 35°C. The instrument will deliver current up to 50 ma, the current limiter adjustable from 5 to 50 ma. Output circuit is floated and guarded.

As a differential voltmeter, the unit has 0.005% accuracy. Input terminals present more than 1,000 megohms input resistance on most ranges.

Circle No. 153 on Subscriber Service Card

Beryllium Oxide Ceramics

Brush Beryllium Co. has developed a series of modified beryllium oxide ceramics applicable to thin-film substrates, transistor heat sinks, microwave windows and capacitor dielectrics.

The Thermalox K series incorporates low loss dielectrics with adjustable dielectric constants in the range 6.5 to 50 for frequencies up to 10 gc. Thermal conductivity of the materials is 60 to 90 Btu/°F/hour at 25°C.

Properties of the ceramics meet all mechanical and electrical requirements, the firm says.

Circle No. 154 on Subscriber Service Card

Magnetic Timer

A magnetic timer with non-destruct memory providing three separate delay periods and an independent reset circuit has been introduced by Elastic Stop Nut Corp. of America's Agastat Div.

The three timed intervals occur sequentially and vary from 0.050 to 500,000 sec. each. Output of each channel is a 2 amp, 18 to 32v dc relay. The memory circuit will hold the time delay at any point in which power removal occurs. Any output relay which has transferred at that point will remain

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transferred when power is reapplied. When power is restored, the timer resumes counting from the point at which power is removed. It can only be reset by applying command signal simultaneous with B+.

Overall accuracy of the unit is 1% over an ambient range from —55° to 71°C and voltage range of 23 to 29v dc, with fixed-condition repeatability of ±0.25%.

Circle No. 155 on Subscriber Service Card

Optical Encoder

A solid-state optical shaft angle encoder capable of operation in extreme environments has been announced by Litton Industries' Encoder Div.

Gallium-arsenide light-emitting diodes are used in place of tungsten lamps, giving the encoder an MTBF in excess of 30,000 hours. The units operate in up to 70 g's shock and survive 11 μsecs. of 105-g shock.

Model IN35-13G2 supplies 4,096 output pulses through 360 degrees of the input shaft, plus a zero reference pulse.

Circle No. 156 on Subscriber Service Card

Analog Readout

An analog readout designed for use with strain gage transducers has been introduced by Statham Instruments, Inc.

Model UR5 provides excitation, control signal conditioning, meter readout, and connection for external recorders. The readout measures pressure, force, weight, linear displacement, and other physical parameters.

Frequency response is from dc to 50 kc. Auxiliary output is 5v at source impedance of 10 ohms. Controls are provided for sensitivity, balance and polarity; meter accuracy is ½% of full scale. Line stability provides a zero shift of less than ± 10%. Power can be 115v or 230v ac, 50 to 400 cps.

Circle No. 157 on Subscriber Service Card

Programmer

Data Science Corp. has introduced a 6-channel timer designed with solderless program change to allow a complex output sequence to be set up in a few minutes.

Model 4015 has output channels employing 2-amp magnitude latch relays programmed by a 12-event timing sequence. Timing up to several hours is derived using magnetic logic to count pulses from a built-in ± 0.02 source.

The 42-cu.-in. unit has an input of 28v dc. Operating environment is -55° to 100°C, 200 g's vibration and 100 g's shock.

Circle No. 158 on Subscriber Service Card

Pratt & Whitney Aircraft has several challenging engineering assignments in the compressor design groups of their Analytical Design Section. Projects under investigation by these groups range from the refinement of turbojet powerplants now in service on commercial and military aircraft through the development of advanced turbine engines to novel turbomachinery for space application.

Current problems include the design and development of supersonic airfoils, high-lift airfoils, extremely small gas turbines for space use and high Mach number, high pressure ratio turbofan stages. Other investigations involve research on unsteady aerodynamics in rotating machinery, aerodynamically excited vibration and boundary layer effects and control in rotating machinery.

compressor design

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Astronaut David R. Scott, prime crew pilot for Gemini 8, gains experience in weightlessness during zero-gravity egress training aboard a C-135 aircraft. Extravehicular activity is planned for Scott during the Gemini 8 mission. In left background, emerging from Gemini mockup, is Astronaut Neil A. Armstrong, Gemini 8 prime crew command pilot.

GEMINI MISSIONS

(Continued from page 15)

and open the hatch in the thirteenth revolution and about 20 hrs. into the mission.

Scott will mount a 16-mm Maurer movie camera on the adapter, climb out of the cockpit, retrieve a nuclear emulsion pack (S-9 experiment) from the adapter and hand it to Armstrong who will stow it in the cabin. Scott will be attached to a 25-ft. umbilical which consists of a nylon restraint tether, several communications leads and a hose delivering oxygen to him directly from spacecraft supply.

A chest pack holds an emergency supply (30 min.) of oxygen, an ejector pump for circulating air, and a heat exchanger for cooling Scott during EVA exercises.

Next, Scott will move to the *Agena,* where he will activate the S-10 micrometeorite collection device by exposing its specially treated surface directly to the space environment.

Using a special cloth, Scott will then attempt to clean exit heating deposits from the *Gemini* windows. "I'll start by trying to clean a small corner first to see if it smears," he explained. After collecting a generous sample of the deposits, Scott will hand the cloth to Armstrong, who will stow it in the spacecraft for analysis on return to Earth.

Still in the 53-min. day-side pass, Scott will evaluate the Air Force's minimum reaction tools against a special work panel mounted on the spacecraft adapter.

Just prior to entering the night side of the orbit, Scott will make his way into the adapter, where he will don the EVA support pack—a 21 x 26 x 17 in. backpack containing two oxygen bottles, Freon under 5,000 psi pressure, a UHF transceiver, a 28-volt battery EVA and special instrumentation. The ESP will provide him with an 83-min. supply of oxygen, 4-min. supply of maneuvering gas for hand-held maneuvering unit (HHMU), and a communications link with Armstrong.

In the second day side of the orbit, Armstrong will undock and back away from the *Agena* to a distance of 100 ft. Scott will extend his range of operation by linking a 75-ft. tether to the umbilical. Using the HHMU, he will move to a position in front of the spacecraft to begin evaluating the maneuvering unit, which is nearly identical to that used by Ed White on *Gemini 4.*

"Rescue" drill—Later, moving to a spot in front of and below the *Agena,* Scott will simulate an HHMU failure. Armstrong will then attempt to "rescue" Scott by maneuvering the spacecraft to the astronaut in distress.

In describing the "semi rescue," Conrad said that the exercise will be made doubly difficult for Armstrong in that Scott will introduce a ½-fps radial velocity at the end of the tether. "Armstrong also has to keep the *Agena* in sight at all times and keep Scott's tether clear of spacecraft thrusters," Conrad added.

This, he explained further, is a demonstration of rescue by spacecraft with direct application to untethered EVA activity. He pointed out that in the event the Lunar Excursion Module ran out of fuel short of rendezvous with the Command Module in lunar orbit, and became unstabilized—perhaps tumbling—the crew might be forced to abandon the vehicle and await pickup by the Command Module.

Prior to re-entering the spacecraft, Scott will abandon the backpack, tether, and HHMU by pushing it away (3 fps in retrograde) from the spacecraft.

A second rendezvous using optical techniques is planned after EVA. Armstrong will initiate a separation maneuver by pitching the spacecraft up 90 degs. and firing aft thrusters to establish an equal-period orbit.

The *Gemini* will move away to a maximum distance of 11 n.mi. before starting back toward the target.

Using a hand-held sextant, Scott will make horizon angle measurements while Armstrong maneuvers the spacecraft for a rendezvous without aid of radar or a computer.

After Scott takes his turn at docking, the spacecraft will back away from the target and the crew will fire the *Agena* PPS to place it into its final orbital resting place 220 n.mi. above Earth.

Other experiments—Several new experiments, in addition to those already mentioned, will be conducted during *Gemini 8,* among them:

—D-15 night-image intensification utilizing a U.S. Navy-developed image orthicon TV camera with an "intensifier" to observe land and sea features under low-light level conditions.

—D-14 UHF, VHF polarization measurements, proposed by the U.S. Navy, to obtain precise measurements of electrons in the ionosphere below the spacecraft and their horizontal gradients as a function of time. ■

contracts

AIR FORCE

$7,100,000—**General Electric Co.**, Philadelphia, initial increment to a $40,000,000 cost-plus-incentive-fee contract for design, development, test, and evaluation of the Mark 12 penetration aids system.

$5,523,464—**Douglas Aircraft Co., Inc.**, Santa Monica, Calif., initial increment to a $18,757,810 contract for launch support services for various space programs.

$1,300,000—**Sylvania Electric Products, Inc.**, Mountain View, Calif., increment to an existing contract for security subsystems for *Minuteman* wings *II* and *III*.

$1,000,000—**Hycon Manufacturing Co.**, Monrovia, Calif., for production of high-altitude aircraft cameras.

$150,000—**Avco Corp.**, Research and Advanced Development Div., Wilmington, Mass., follow-on contract to study spacecraft protection against harsh environments.

ARMY

$3,950,005—**Raytheon Co.**, Norwood, Mass., modification for communications equipment.

$2,240,000—**Western Electric Co.**, New York City, modification to a previously awarded contract for improved modification kits for *Nike Hercules* weapon system.

$2,000,000—**General Electric Co.**, Utica, N.Y., modification for classified electronic equipment.

$1,809,850—**Beech Aircraft Corp.**, Wichita, Kan., fixed-price contract for guided missile target (MQM61A, model 1025).

$1,500,000—**Electronics Modules Corp.**, Timonium, Md., fixed-price contract for classified electronic components.

$1,200,000—**University of Illinois**, Urbana, Ill., modification for an additional twelve months work on a scientific research program.

$294,300—**Smith and Sapp Construction Co.**, Orlando, Fla., for additional utility installations in the Kennedy Space Center's industrial area.

$203,052—**Ryan Aeronautical Co.**, San Diego, Calif., for repair parts for *Firebee* target vehicles.

$95,219—**Marquardt Corp.**, Van Nuys, Calif., for advanced propulsion test facility research.

$80,000—**Philco Corp.**, Newport Beach, Calif., for *Shillelagh* missile system FY 1966 research, development, test and evaluation program. Also, $39,354 for *Shillelagh* missile design changes.

NAVY

$16,000,000—**Hughes Aircraft Co.**, Culver City, Calif., modification for additional funding for the *Phoenix* missile system for FY 1966.

$2,108,974—**Bendix Corp.**, York, Pa., fixed-price contract for target detecting devices for *Talos* missile systems.

$1,561,198—**International Telephone and Telegraph Corp.**, Harrisburg, Pa., fixed-price contract for lead electrical wire for 2.75-in. rockets.

$1,365,080—**Hydromatics, Inc.**, Bloomfield, N.J., fixed-price contract for ball valve sets for *Polaris* submarines.

$1,176,615—**General Dynamics Corp.**, Pomona Div., Pomona, Calif., for replacement parts for Mk 8 mod 1 *Terrier* missiles.

$300,000—**Lockheed Propulsion Co.**, Redlands, Calif., for the production of 98 solid-propellant Javelin II rocket motors.

$198,125—**Norris Thermador Corp.**, Vernon, Calif., for ballistic assembly stabilizing rods for Mk 16 mod 1.5-in. rocket motors.

$180,000—**Goodyear Aerospace Corp.**, Akron, Ohio, for field engineering services to provide technical assistance and instruction in connection with test, installation, repair, evaluation and servicing of *Subroc* missile system.

NASA

$426,004—**C.G.S. Scientific Corp.**, Southampton, Pa., from Ames Research Center for man-rated environmental control evaluation chamber.

$312,011—**Stanford University**, Stanford, Calif., from Ames Research Center for radio propagation experiment for project *Pioneer*.

$96,959—**General Dynamics Corp.**, Convair Div., San Diego, Calif., from Marshall Space Flight Center for studies of hydrogen-oxygen reaction.

Curtiss-Wright Corp., Wood-Ridge, N.J., from the Manned Spacecraft Center to develop a new attitude control and space maneuver engine. Amount not disclosed.

INDUSTRY

$990,000—**Borg-Warner Corp.**, Pesco Products Div., Bedford, Ohio, from **North American Aviation, Inc.**, Anaheim, Calif., for auxiliary hydraulic power supplies for the *Minuteman II* missile.

$400,000—**Bendix Corp.**, Eclipse-Pioneer Div., Teterboro, N.J., from the **Boeing Co.**, Seattle, Wash., for command signal decoders for the *Minuteman* system.

$176,000—**Consolidated Electrodynamics Corp.**, Palo Alto, Calif., from the **Boeing Co.**, Seattle, Wash., for a mass spectrometer system, used to develop and investigate new materials and to develop new techniques for process control. It will be used in connection with the *Minuteman* program.

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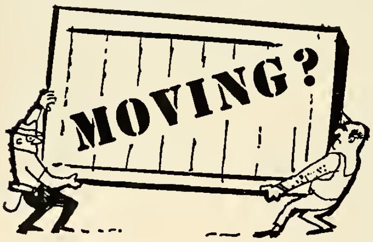

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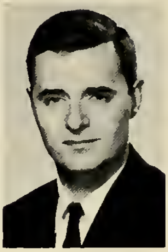
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Wells McTaggart: Elected to the board of directors of Rocket Research Corp. **Vincent M. Jolivet** was elected to vice president of the company. Jolivet is professor of finance and statistics at the University of Washington and will direct business, financial, and administrative activities at Rocket Research.

E. D. Kenna: Elected group vice president of Avco Corp. in charge of the missiles, space and electronics group. **James R. Dempsey,** formerly president of the Convair Div. of General Dynamics Corp., has joined Avco as vice president of the group and deputy to Kenna.

Raymond Azar, Gerald Bradley, James Crawford and **Wilton Parker:** Elected to the board of directors of the Garrett Corp. All four are officers of the corporation.

Daniel R. Bannister: Appointed vice president of operations for Dynalectron Corp. He will be in charge of the company's six operating divisions.

Charles D. Manhart: Elected vice president of Electronic Communications, Inc., and general manager of the company's standard precision division. He was formerly vice president and general manager of the defense systems division of the Bunker-Ramo Corp.

Dr. Jacques Piccard: Signed a five-year contract with Grumman Aircraft Engineering Corp. The company has obtained exclusive rights to his services as consultant, designer, and representative in the design, manufacture, and operation of submersible vehicles and future planned undersea studies.

William H. Houghton: Elected vice president of finance of Bendix Corp. **Allen M. Harrelson** was named vice president and treasurer of the company.

Harry Letaw, Jr.: Elected a director of MEMCOR, Inc. He is a general consultant. Formerly, he was vice president and general manager of Bunker-Ramo Eastern Technical Center, Inc.

F. J. Dunleavy: Named executive vice president of International Telephone and Telegraph Corp. **John C. Lobb** was also named an executive vice president. **Hart Perry** was named executive vice president of finance and retains his post as treasurer. Dunleavy has served as president of ITT Europe, Inc., since January 1965; Lobb has been a vice president since 1963.

Edward C. Utz: Appointed a vice president, operations, of International Telephone and Telegraph Corp.'s wire and cable division. He was formerly vice president, administration, for the division.

Leonard S. Sheingold: Appointed to the Defense Science Board of the Department of Defense through 1969. He is vice president of advanced technology for Sylvania Electronic Systems.

John C. Hamaker, Jr.: Elected president of the New England Materials Laboratory, a subsidiary of Vasco Metals Corp. He will continue his present assignment as corporation vice president of technology.

John T. Gordin: Elected to the board of directors of Fulton Industries, Inc. **S. Mays, Jr.,** was also elected to the board.

Henry V. Kobin: Named a member of the board of directors of U.S. Industries, Inc.

Lawrence Zeitsoff: Elected to the board of directors of Consultants & Designers, Inc. He is a corporate vice president and has served as general manager of the company's technical services division since 1960.

Roger W. Wallace: Appointed president of Sunbeam Electronics, Inc. He has been vice president, manufacturing, and member of the board of directors of John Oster Manufacturing Co., a Sunbeam Corp. subsidiary, and will retain these positions.

William E. Hanneman: Named vice president and director of operations for the National Connector Corp. He will be responsible for coordinating activities of the firm's four major departments—manufacturing, engineering, marketing and quality control.

Edwin L. Deck: Appointed vice president of operations for Potter & Brunfield Div. of American Machine & Foundry Co. He will be responsible for all phases of manufacturing and applications engineering for the company's plants in the U.S.

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MARCH

Geometric Optics Seminar-in-Depth, sponsored by the Society of Photo-Optical Instrumentation Engineers, White Sands Chapter, Hilton Inn, El Paso, Tex., March 7-8.

Third Space Congress, sponsored by the Canaveral Council of Technical Societies, Cocoa Beach, Fla., March 7-8.

Electric Propulsion Meeting, sponsored by the American Institute of Aeronautics and Astronautics, San Diego, Calif., March 7-9.

Western Metal & Tool Conference and Exposition, sponsored by the American Society of Metals and American Society of Tool & Manufacturing Engineers, Los Angeles, March 7-11.

Electronics Industries Assn. Spring Conference, Statler Hilton Hotel, Washington, D.C., March 7-10.

1966 Spring National Convention of the Society for Nondestructive Testing, Biltmore Hotel, Los Angeles, March 7-10.

Symposium on Manufacturing In-Process Control and Measuring Techniques for Semiconductors, sponsored by the Electronics Branch of Manufacturing Technology Div., Air Force Materials Laboratory, Wright-Patterson AFB, and Motorola, Inc., Semiconductor Products Div., Hiway House, Phoenix, Ariz., March 9-11.

"How To Do Business with the Government and Prime Contractors in Defense and Aerospace Projects," one-day seminar, sponsored by the Strategic Industries Assn., International Hotel, Los Angeles, March 11.

Seminar on Atmospheric Physics, sponsored by the American Institute of Physics, Shoreham Hotel, Washington, D.C., March 14.

Fourth Goddard Memorial Symposium, "Space Age in the Fiscal Year 2001," sponsored by the American Astronautical Society, Sheraton Park Hotel, Washington, D.C., March 15-16.

50th Anniversary Meeting of the Optical Society of America, Shoreham Hotel, Washington, D.C., March 15-18.

Fourth International Aerospace Instrumentation Symposium, sponsored by the Instrument Society of America, Cranfield, England, March 21-24.

International Convention, sponsored by the Institute of Electrical and Electronics Engineers, Coliseum & New York Hilton Hotel, New York City, March 21-25.

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The Space Race Pace

THE DREAM HAS BEGUN to dissolve into reality. Nearly five years ago, President Kennedy outlined to Congress an ambitious and not too precisely defined project to land an American manned expedition on the Moon by the end of the decade. Late last month, in a lift-off that impressed even veteran Cape observers, the 1.6-million-pound thrust of *Saturn IB* pushed the first *Apollo* Moonship into space on an unmanned ballistic trajectory that inaugurated the *Apollo* flight program.

Much has happened since the delivery of that bold proposal in May of 1961. The man who presented it is gone. The Cape that was then Canaveral now is Kennedy. Fighting in Vietnam has widened into a full-scale war. But the lunar-landing project has moved ahead with a relentless energy that promises that the goal which once seemed so distant may now be met.

Late this year, *Apollo* is to carry its first crew into orbit. Then, in 1967, the *Saturn V* will be ready for flight and the project to reach the Moon will enter its final stages.

The Soviet Union, meanwhile, is stepping up its space activity in ways that suggest the Russian lunar project also is moving ahead on schedule toward a manned landing. With the evidence of *Luna 9* that the Moon's surface is indeed solid, the Soviets can concentrate once again on the flight hardware and flight program to get men there. The launch of the two dogs Veterok and Ugolyok in what appears to be the big new *Proton* spaceship indicates that the Soviets are preparing to establish a manned space station in a long-duration orbit once the radiation findings of *Cosmos 110* are analyzed.

The next step to be expected is the rendezvous and docking of ferry flights with the space station. The Soviets then will have the experience and capability to begin assembling their lunar expedition in orbit, for it appears they are going the Earth-orbital route as opposed to the lunar-orbital approach of Project *Apollo*.

The Russians also have continued an active interest in unmanned planetary exploration, as demonstrated by last week's crash landing of a probe on Venus and the fly-by of another craft. The current American lead in this phase of space exploration now is in danger of being overtaken, particularly in view of economies in the Fiscal 1967 budget of the National Aeronautics and Space Administration.

The next American fly-by of Venus is not scheduled until late next year, when we will attempt to learn more about the interestingly high temperatures reported by *Mariner II*.

We must take care, however, that all of this activity in the manned lunar program and in unmanned planetary exploration does not obscure some presently less dramatic but equally promising projects in the NASA budget. Congress may be tempted to reduce the funds for some of these smaller programs in order to maintain or increase the timetable of planetary or lunar exploration.

WE ARE THINKING PARTICULARLY of the forthcoming series of launches of the *Applications Technology Satellites (ATS)*. The first of these is scheduled for December of this year, but there is not as yet a widespread appreciation of the potential benefits in store in the Goddard program.

These satellites will be mostly in synchronous orbit and will demonstrate the feasibility of a wide variety of uses. Not the least of these is a project which we have urged for some time—the transmission to Earth of a photograph of Earth itself as seen from space. As we have said previously, the first nation to accomplish this will score a major propaganda triumph. Such a photograph is assured of front-page newspaper play throughout the world. It also will have great scientific merit in the assessment of various theories about the shape of the Earth.

The *ATS* satellites also will provide a television link between the United States and the Far East, bringing that critical area into closer communication with this country.

Potentially the most economically useful capability to be shown by *ATS*, however, lies in the field of monitoring the Earth. The satellites will be able to collect data from a wide variety of sources and transmit them to Earth instantly or upon command.

ATS can follow the path of the winds through balloon-borne transmitters, trace ocean currents by the information from transmitting buoys, track the movements of transmitter-equipped aircraft across the Earth's surface, or even follow migrating herds of land animals or sea mammals which have been "tagged" with transmitters.

The many-fold increase in accuracy in long-range weather forecasting, so important to farmers and many others, is but one benefit that will have an enormous economic pay-off. The whaling industry, for another, would profit greatly if it were enabled to closely track the great herds of whales as they migrate. Scientists will learn many things through the ability to monitor natural events on Earth from a vantage point in space.

ATS promises to bring the benefits from his space dollar home to the taxpayer more quickly than will *Apollo* or the explorations of Mars and Venus.

When a merchant can plan his inventory of raincoats, air conditioners or snow tires more accurately, he will have an immediate appreciation of why we are going into space.

We hope Congress will not let the dramatic lure of the bigger, more expensive programs—so evident these past few weeks—overshadow the value of utilitarian projects such as *ATS*.

William J. Coughlin

satellite communication

STATE-OF-THE-ART

1958

During 1958, a tube for use in ground terminals with sufficient power and bandwidth at X-band was required for satellite communication.

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STATE-OF-THE-ART

1964

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STATE-OF-THE-ART

1966

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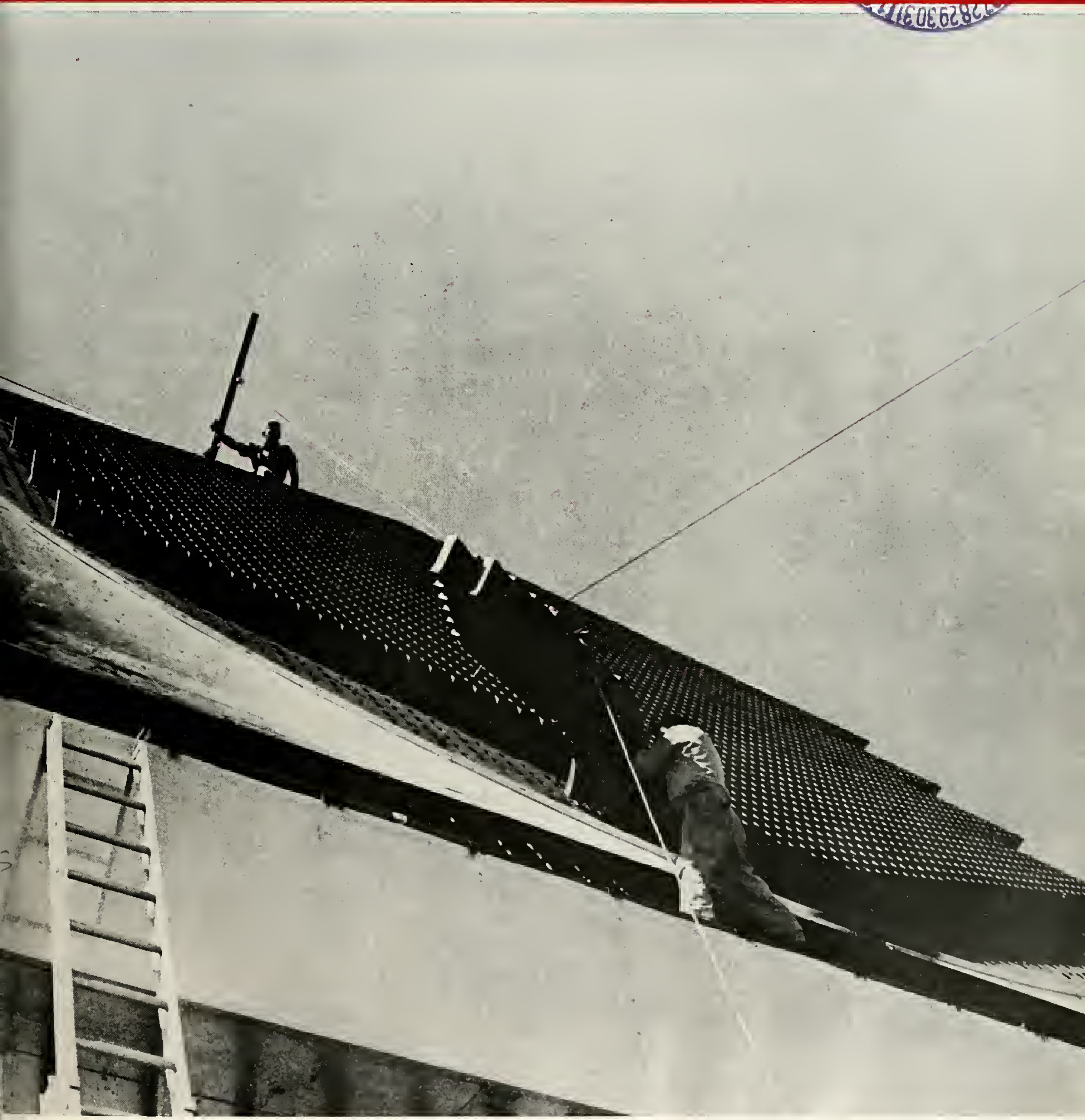

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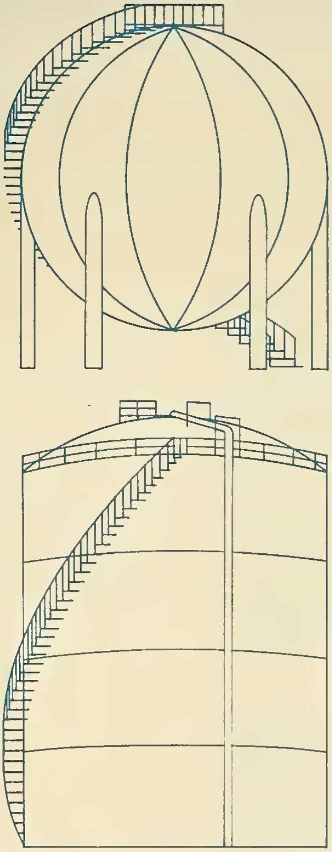

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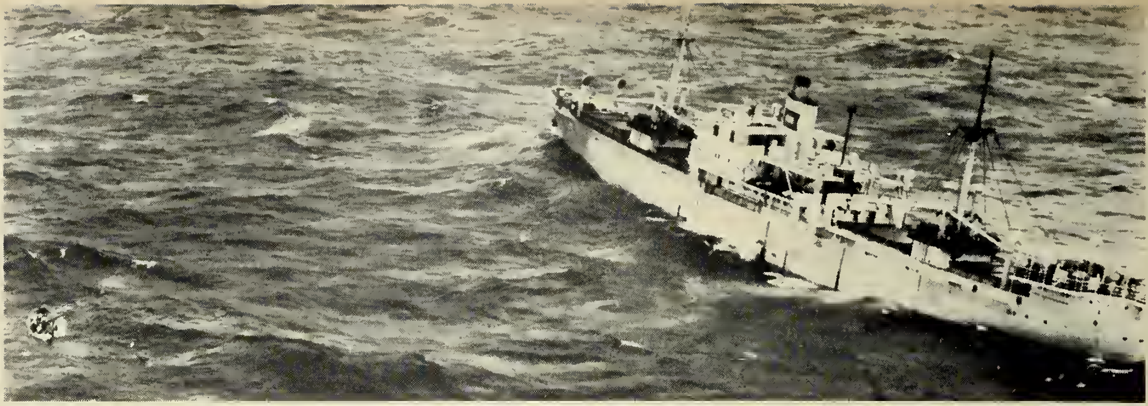

Communications coordinated rescue efforts when Norwegian freighter Lionne foundered off Greenland. At left, in a lifeboat, is part of the ship's crew.

Bell System Communications help the U.S. Coast Guard watch over the North Atlantic

From the U. S. Coast Guard Communications Center in Manhattan speed the orders for search and rescue operations covering 4,500,000 square miles of the North Atlantic.

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Other Bell System phones link the Coast Guard with Navy, Air Force and overseas aircraft controllers and with military communications networks.

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The network handles everything from weather reports to multi-ship rescue efforts.

When a Coast Guard station or cutter receives a distress call, a teletypewriter feeds the position of the stricken ship to a computer in New York. The computer lists vessels within rescue range. The ships are directed to get to the scene as quickly as possible.

The Bell System's unified research, manufacturing and operating capabilities give the U. S. Coast Guard the means to minimize trouble at sea.

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Volume 18, Number 11 March 14, 1966

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THE COVER

Workmen at White Sands Missile Range fit honeycomb section over elements of new HAPDAR phased-array radar antenna. Radar represents a cost breakthrough for large arrays by use of single feed system and passive phase-shifting techniques. Unit may find use at missile silos. See p. 15.

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letters

None If By Sea

To the Editor:

A reprint of your Feb. 28 editorial ("None If By Sea") appeared in the *London Daily Express.* I, like many readers no doubt, was impressed with your observations and powerful writing.

You are right in your summing up, and your Marquis de Sade paragraph was devastating. Would that you could become a naturalised British subject and enter the House of Commons. We could do with many people of your outspoken hit-the-nail-on-the-head type.

The majority of British people deplore the run-down that has been carried out by men of all parties. We wish we had people that had a bit of fire in their bellies. Britain as you rightly said has the brains, but look how the handful at the top throw away the chances. At the moment we shall probably lose out on the hover-craft, as we did with the jet car, penicillin, air-refueling, and a host of other inventions or discoveries. To scrub out the TSR. 2, probably the finest plane in the world, and then buy F-111's, which I understand incorporate swept-back wings (Barnes-Wallis invention not appreciated in Britain), was the acme of folly. I'm afraid I'm not much of a hand at putting on paper what I and millions of others feel—but you were dead right.

Unfortunately we are, and have been, governed by the people who think of every other country, other than their own. Good luck to you.

Charles H. Gower
London, Gt. Britain

Space-Age Jargon

To the Editor:

Re: Space-Age jargon.

In your article "Tests Set to Define (Lunar) Landing Hazard," M/R, Dec. 20, p. 36, you report that "Chapman says he has no doubt that the objects (tektites) are re-entry bodies . . ."

As we learn from Webster's Dictionary, and saw the re-entry warhead demonstrated by General Eisenhower on TV in 1957, and hear about re-entry ICBM, etc., we understand that a re-entry body should originate from the Earth. It leaves the surface of the Earth by entering into the atmosphere, and then goes through the atmosphere and into outer space. When it comes back, such as a re-entry ICBM, it enters again into the atmosphere, but from above, and then falls on Earth if it survives the heat. I know that Dr. Chapman is one of the staunchest advocates on lunar origin of the tektites. Thus, it seems that he may not call his tektites "re-entry bodies." I should think that there is a need for clarification of the Space-Age jargon, so that we may communicate with each other without getting into undue semantic difficulties. Perhaps the Research Department of MISSILES AND ROCKETS may apply a grant from NASA to compile a volume of the jargon for the benefit of all interested people, and the public.

James M. S. Sun
Albuquerque, N.M.

Space Communications

To the Editor:

I have read with interest the special report on space communications contained in the MISSILES AND ROCKETS issue of Jan. 31. M/R is to be congratulated on the thoroughness of its report.

Mr. Rex Pay's article was particularly interesting, because it deals with one of the most fundamental questions—that is, how fast and to what extent will communications satellites revolutionize the communications industry?

I would like to see another report like this one next year.

F. H. Gedicks
TRW Inc.
Redondo Beach, Calif.

Hospital Fallout

To the Editor:

Congratulations on a fine article "Hospital To Benefit from Space Work," by Heather M. David, M/R, Feb. 28, p. 26. The reporting, as usual, was factual and well put.

Naturally, we are always pleased to receive recognition in the press of our work, but it is particularly gratifying when an article appears which reflects the depth of comprehension that yours does.

James A. Reeves
President
Spacelabs, Inc.
Van Nuys, Calif.

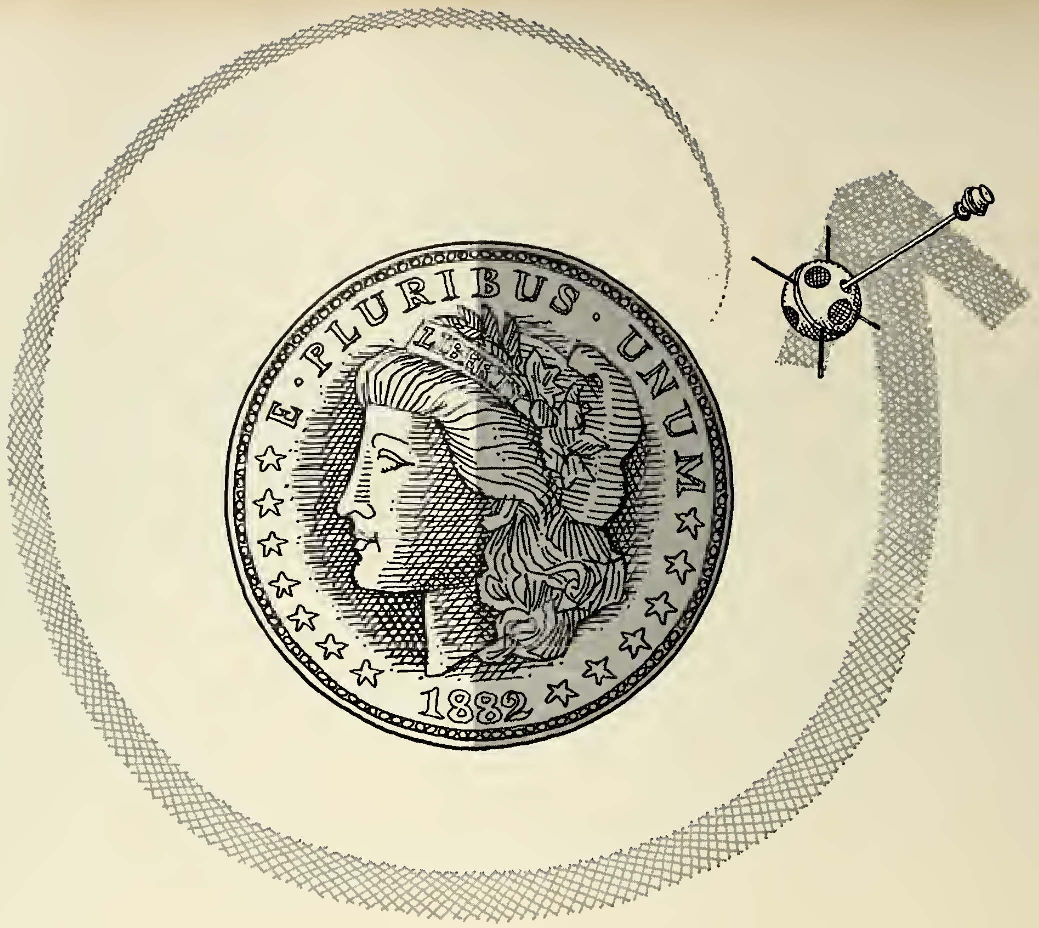
Jet Gift

To the Editor:

In your Feb. 28 editorial you mention that the British gave us, amongst other things, the jet engine and the first jet airliner. I thought the Italians invented the jet engine. I would like to be enlightened.

J. McWilliams Stone
President
DuKane Corporation
St. Charles, Ill.

It is true that Secundo Campini of Italy's Caproni Company developed a jet propulsion system which was successfully flown in August, 1940, in what may have been the first jet-propelled aircraft flight. However, in 1930 Air Commodore (then Flying Officer) Sir Frank Whittle of Britain applied for a patent involving a centrifugal compressor. This led to the first British airborne jet engine in May, 1941. During the same year, the first Whittle production engine was sent to the United States, which at that time had not developed a jet of its own.—Ed.



Long life in space is executive emphasis...

Over 50% of profit and investment funds go to reliability programs

Today, 100 percent reliable operation of complex, long-life space systems is not always possible. However, executive emphasis now can help attain it in the future. At G.E.'s Missile and Space Division, more than half of all profit and investment funds are devoted to long-life reliability programs. The objectives: maintain uniform reliability standards and techniques; initiate projects to accomplish more effective equipment designs; instill and measure realistic goals. In all functions, at all levels, achieving long life in space is the ultimate goal of the . . .

MISSILE AND SPACE DIVISION

162-14

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The Countdown

WASHINGTON

Military Space Stable at $2 Billion

U.S. military space program will remain stable at or below the $2-billion level for the near future. That was the word from the Dept. of Defense at the first round of Advanced Planning Briefings in Boston. Daniel J. Fink, deputy director for strategic and space systems in the Directorate of Defense Research and Engineering, also anticipated more emphasis on multi-purpose unmanned military satellites.

Army Studies Missile Second Sources

Army is focusing on at least three new missile systems as likely prospects for second-source procurement—possibly in FY '68. These include the *TOW* and *MAW* anti-tank and assault weapons and the *Chaparral* air-defense missile. Experience with competitive procurement for *Shillelagh*, for which second production sources now are being evaluated, will have a big impact on the future decisions.

Here's a Peek at Early Warning Systems

Improvements to U.S. early-warning satellites are in the works. Dr. John Foster, director of Defense Research and Engineering, alluding to the already re-oriented and expanded *MIDAS* program during recent testimony before the Senate Aeronautical and Space Committee, said capabilities of the early-warning satellite are being expanded. New capabilities include: location of ballistic missile launch points, detection of nuclear detonations for missile-strike reporting, attack assessment, and additional nuclear test ban monitoring.

Minuteman II Unit Reaches Strength

Minuteman II will reach its first full 50-missile squadron strength deployment this month. Location: Grand Forks AFB, N.D. Meanwhile, the missile modernization program at *Minuteman* Wing 4, Whiteman AFB, Mo., is officially under way in the start of an effort which ultimately will replace 800 *Minuteman I's*.

Air Force Sets Up Payload Office

Air Force is establishing a central office to handle requests from NASA and other DOD agencies seeking to make use of its secondary payload space capabilities. Arrangements for such launch support until now had been on an informal basis. A three-step screening process has been set up under which a panel of experts will evaluate all such payloads.

NASA Looks at Modular Satellite

NASA is studying feasibility of a small modular scientific satellite which could be adapted with short lead time to a variety of *Explorer* missions. Other new projects under study: a *Solar Pioneer* for interplanetary exploration which would include close approaches to the Sun and a *Galactic Pioneer* for exploration beyond the planet Jupiter.

Lance Production Requirements Outlined

Army Maj. Gen. John G. Zierdt, chief of the Army Missile Command, told the Boston Advanced Planning Briefing that production requirements for the *Lance* short-range tactical missile will reach several hundred million dollars over the next several years. Zierdt said additional sales to other governments and other services (M/R, Oct. 18, p. 21) are in the offing. Active study programs are under way to extend the range of both *Lance* and *Pershing*.

Army Seeks New Air Defense System

Army has confirmed that it is studying an improved, highly mobile field air defense system (M/R, Nov. 1, p. 14) which would represent a follow-on to the man-portable *Redeye* missile and augment the new *SAM-D* system now going into development. The requirement is based on the need for an inexpensive missile with all-weather capability against high-performance aircraft which can be deployed in large numbers. DDR&E officials support the Army view.

Flyable Nuclear Rocket Cost Estimated

It will cost $2.6 billion through 1978 to develop a flyable nuclear rocket stage, including work on the vehicle itself. That's the estimate from Harold Finger, manager of the joint NASA/Atomic Energy Commission Space Nuclear Propulsion Office. He told a Congressional committee last week that $800 million already has been spent on the *Rover* system. Cost of the large NERVA program is seen as $1 billion from 1967 through the flight program in 1978.

INDUSTRY

Comsat Seeks West Virginia Site

Comsat Corp. is looking for a site in West Virginia for its next Earth station, to be placed in operation in mid-1967. The company is expected to file for Federal Communications Commission approval for this station in the near future. Comsat already has announced plans to construct a station in Puerto Rico. It has joined AT&T in asking the FCC to deny a request from ITT Wire & Cable, Inc., for approval of its plan to build a Puerto Rican ground station. The FCC ruling giving Comsat sole control of the three existing initial U.S. ground stations will expire near the end of 1968.

INTERNATIONAL

Japan To Build Nike-Hercules

Japan is planning production of *Nike-Hercules* surface-to-air missiles under U.S. license. The Japanese Defense Agency had planned to purchase the weapons as part of the latest defense buildup (M/R, Jan. 29, p. 9). But after talks with visiting Dept. of Defense officials early in February, the decision was made to build the missiles locally. Cost of hardware for each of three battalions planned is estimated at $28 million.

British Build New Guided Missile Ships

Britain's Ministry of Defence reports that new Type 82 guided missile destroyers, to be ordered later this year for the Royal Navy, will carry both *Seadart* and *Ikara* missiles, together with long-range sonar equipment. The surface-to-air *Seadart* also has a limited anti-ship capability. *Ikara* is a long-range anti-submarine weapon developed in Australia.

France To Develop Tactical Missile

Work on a new French tactical missile designated *SSBT*, to be deployed in the 1970's in a system with the planned Anglo-French Jaguar fighter-trainers and variable geometry twin-jet fighters, is to start in 1969, according to defense officials in Paris. Range is to be about 450 mi.

Research Submersibles: A report from General Dynamics

New breed of vessel:

A hundred and thirty feet down in the Aegean Sea, a Byzantine galley had hidden its secrets for almost fifteen centuries. Then in 1964, University of Pennsylvania Museum archeologists mounted paired cameras on a new research submarine, Asherah, and learned more from the three-dimensional photographs obtained in one "flight" over the wreck than had been possible from weeks of scuba diving.

This was the first of dozens of undersea jobs already done by Asherah. The Asherah is the 339th—and at 17 feet long, the smallest—submarine built by General Dynamics. For comparison, the Holland, the very first submarine we delivered to the Navy in 1900, was 54 feet long. Over the years, we have built the prototypes of most classes of United States Navy submarines, including its nuclear-powered undersea ships.

But the true manned research submarines are really a new breed of boat. Less than a score now exist.

Depth and mobility:

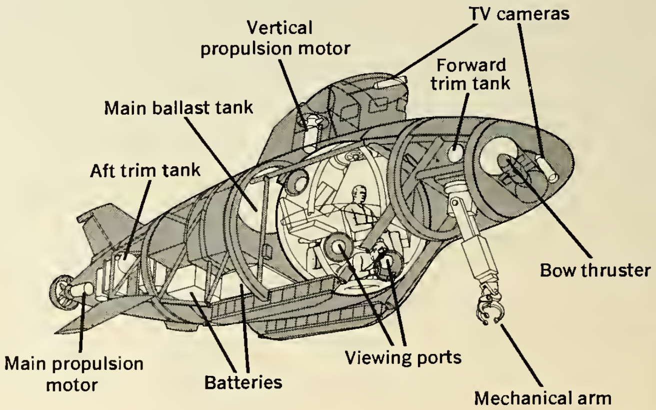
Unlike bathyscaphes, designed to drop to great depths but remain relatively immobile for passive observation, the new research submarines must have depth capability, the ability to perform useful work, and the mobility to survey extended areas at a reasonable speed.

Asherah is one of the first true research submarines. It can dive to 600 feet (World War II subs rarely dived much below 300 feet), stay submerged for ten hours, cruise at three to four knots, move in all directions. An improved sister ship, Star II, is made of the same HY-80 steel that goes into nuclear submarines; it has depth capability to 1,200 feet.

The Asherah beneath the Aegean Sea.

A larger boat we call Star III (see cutaway drawing below) is built of even tougher HY-100 steel. It has a cruising depth of 2,000 feet, and is equipped with an external mechanical arm that has interchangeable "hands"—a clamshell grip, a wire cutter, and a "three-finger" which can pick up a pencil or a 200-pound weight, or manipulate a valve.

CUTAWAY OF STAR III



The Aluminaut, the largest research sub so far, was built by General Dynamics for Reynolds International to prove, among other things, the feasibility of aluminum as a hull metal. The 51-foot Aluminaut is designed to operate at depths up to 15,000 feet, under pressures up to more than 7,000 pounds per square inch. Aluminaut, in early sea trials, has cruised as deep as 6,250 feet, and remained submerged for over 30 continuous hours. A World War II military submarine rarely remained submerged for more than 24 hours.

Problems and needs:

These early research subs still have many limitations of speed, range and submerged endurance. They require back-up by a mother ship and have to be carried or towed to a job location.

This last "limitation" can sometimes be an advantage. Asherah and Star II, for example, are small enough to be rushed by air for a rescue operation.

But subs with many special characteristics will be needed for exploring—and for exploiting—the sea.

Some vessels will have to withstand pressures up to 10,000 pounds per square inch, to allow them to penetrate into mid-ocean abysses four miles deep. Work subs for, say, mining will have to be stable enough in a buoyant environment not to be whipped about in reaction to the force of their own tools.

We have already done a study for the Bureau of Fisheries showing feasibility of a submarine to track oceanic fish. It would be 160 feet long, carry 31 persons at speeds up to 20 knots, and could cruise submerged for up to 90 days.

Right now, we don't think there will ever be one single all-purpose type of research-work submarine. Just as land vehicles range from motor scooters to 20-ton earthmovers, so will most manned submersibles be designed and built for special purposes.

General Dynamics is a company of scientists, engineers and skilled workers whose interests cover every major field of technology, and who produce: aircraft; marine, space and missile systems; tactical support equipment; nuclear, electronic and communication systems; machinery; building materials; coal and gases.

GENERAL DYNAMICS

The Missile/Space Week

NASA Gets Satellite Bids

Eight firms have submitted bids to NASA to study feasibility and preliminary design for an orbiting data relay satellite system.

The successful bidder will receive a six-month fixed-price contract for a study to determine the characteristics of a system of ground stations and data relay satellites in synchronous Earth-orbit above the equator. Data transfer between spacecraft and NASA mission control centers would be speeded through linking spacecraft directly with central ground stations through data relay satellites.

The firms submitting proposals are: Booz-Allen Applied Research, Inc.; General Electric Co.; Hughes Aircraft Co.; Hydro-Space Systems Corp.; Lockheed Missiles and Space Co.; Radio Corp. of America; Systems Sciences Corp.; and TRW Systems.

The system could provide for continuous contact with the spacecraft. Signals transmitted from the spacecraft could go directly to the nearest orbiting data relay satellite and thence to a ground station. At present, contact is broken when the spacecraft leaves a ground station's line of vision and is not renewed until the spacecraft comes in view of the next station below its orbit.

Shots of the Week

Brazil successfully fired another *Nike-Asp* atmosphere-probing rocket from its Barrier of Hell Base near Natal March 3. The solid-fuel rocket reached a height of 18 mi. and was exploded from the ground, releasing a cloud of metallic particles and sodium gas for radar observations.

A *Polaris A-3* was launched March 3 from the atomic submarine Lewis & Clark, cruising submerged off Cape Kennedy.

Second NERVA Firing Set

NASA plans to fire the NERVA nuclear rocket engine at full power for a second time on March 16.

The space agency officials made the decision following the completely successful demonstration of the breadboard engine on March 3. In that test, the engine was fired for six minutes, during which it operated at full power for 93 seconds. The engine was restarted 2½ hrs. later and operated at intermediate power levels for 15 minutes.

Top power of the NERVA is 1,100 megawatts, or a thrust of 55,000 lbs.

NASA has already decided not to flight-test the NERVA engine. The successful firing, however, should speed the development and eventual flight testing of the NERVA II engine. That engine—which will have a thrust of 250,000 lbs.—will receive initial hardware funding in FY '67.

GD Forms Marine Group

General Dynamics Corp. has announced formation of a new Marine Systems Group comprised of the corporation's Electric Boat division at Groton, Conn., the Quincy shipyard at Quincy, Mass., which is being made a full operating division, and the Electro Dynamic division at Avenel, N.J.

Carl G. Holschuh, named group vice president for the new group will direct the organization from General Dynamics' New York headquarters.

Company President Roger Lewis said the group is being formed in response to the "expanding requirement for complete military and commerical systems. We feel there are more promising opportunities for wider application of the corporation's marine capabilities in the fields of nuclear and conventionally powered surface vessels, undersea systems for exploration, mining, harvesting of food and transportation, and marine system components of all types."

DOD Pushing R&D Delivery

Research and development currently sponsored by the Dept. of Defense in support of the Vietnam effort is committed to delivery of advanced implements, systems and techniques within 6 to 18 months, Dr. Finn J. Larsen, deputy director of research and engineering, told the Annual Spring Conference of the Electronic Industries Assn. in Washington last week.

The major difference in this conflict as compared with previous U.S. war efforts, Larsen said, is that for the first time, we are dedicated to rapid R&D response. Five to twelve years for an R&D program cannot be tolerated, he said. The current DOD concept is to spend money wherever necessary and to employ technology wherever applicable to assure the continued high ratio of enemy-to-allied forces casualty rates.

A telegram from headquarters of Gen. William C. Westmoreland, commander of U.S. forces in Vietnam, citing an R&D need, is now considered equivalent to a requirement and is handled accordingly, Larsen stressed.

Cool Gas Generation Probed

Rocket Research Corp., Seattle, has received a $95,794 contract from the Air Force for development of low-temperature gas generator technology.

This contract will be conducted under the sponsorship of the Air Force Rocket Propulsion Laboratory, Research and Technology Division, Edwards Air Force Base, Calif., an agency of the Air Force Systems Command.

The objective of the program is to characterize monopropellants, based upon hydrazine, plus additive diluents, which produce clean outlet gases ranging in temperature from 2,200° F down to 175° F when passed through a catalytic chamber.

DSSP Funds Spelled Out

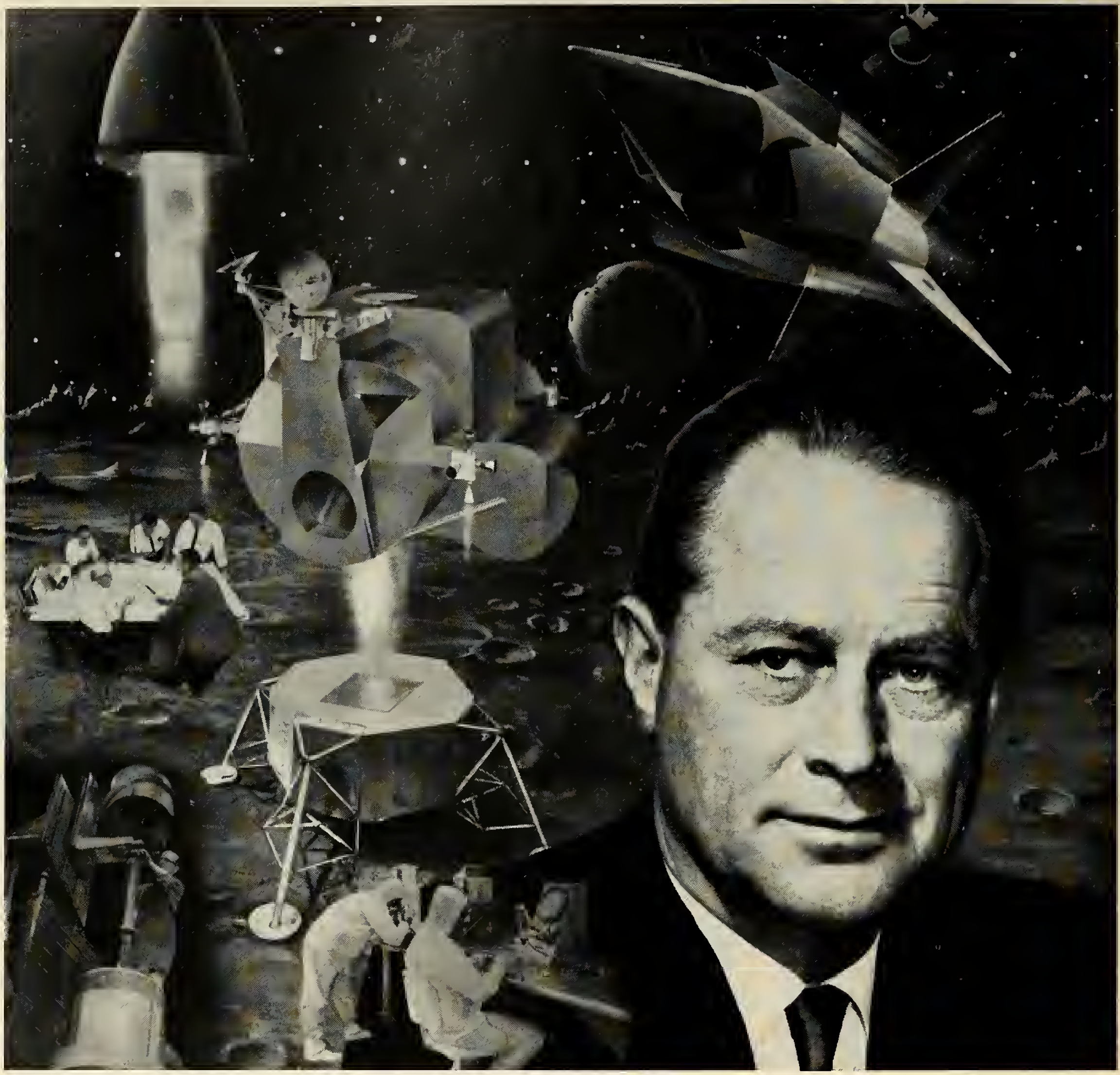
The Defense Dept. is asking for some $22 million in Fiscal Year 1967 for the Navy's deep-submergence systems project (DSSP), according to Dr. John S. Foster, Jr., director of defense research and engineering, in a statement last week before the Senate Committee on Armed Services and the Subcommittee on Defense Appropriations.

Since the contract for the prototype development and production of the deep-submergence rescue vehicle is estimated at $5 or $6 million, there would be $15-$16 million left for the remainder of the program. The contract is expected to be let soon.

As yet, there are no cost estimates for the six operational rescue vehicles, the in-house expenditure for development of these vehicles, or the development expense for four search vehicles, having the eventual capability to reach depths of 20,000 ft.

Saturn Contract Converted

NASA has signed a supplemental agreement with Boeing Co. converting the company's *Saturn V* first



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stage (S-IC) contract from a fixed-fee to an incentive-fee contract.

It is the first *Saturn* stage contract to be converted to an incentive type.

The modification covers conversion of the first three "schedules" under the Boeing contract.

Under schedule 1, valued at $850 million, Boeing is responsible for the manufacture, assembly, and test of two S-IC ground test stages and eight flight stages and the supply of major components for two S-IC test stages and two flight stages.

Schedule 2 calls for Boeing to provide systems engineering and integration support in development of the three-stage *Saturn V* space vehicles. Schedule 3 directs the contractor to provide *Saturn V* launch support at the Kennedy Space Center.

Martin, Bendix Team for AAP

Martin Co. and Bendix Corp. will make a joint bid for the payload integration contract for NASA's *Apollo* Applications Program.

The team is seeking a nine-month contract for a first-phase study of scientific and engineering considerations of AAP. Program payload integration is under the direction of Marshall Space Flight Center.

Johnson Is Goddard Winner

President Lyndon B. Johnson will be awarded the Dr. Robert H. Goddard Trophy for 1966 for his legislative and executive leadership in the U.S. space program.

The award, originated by MISSILES AND ROCKETS, is presented annually by the National Space Club to the individual making the greatest contribution to advance U.S. astronautics.

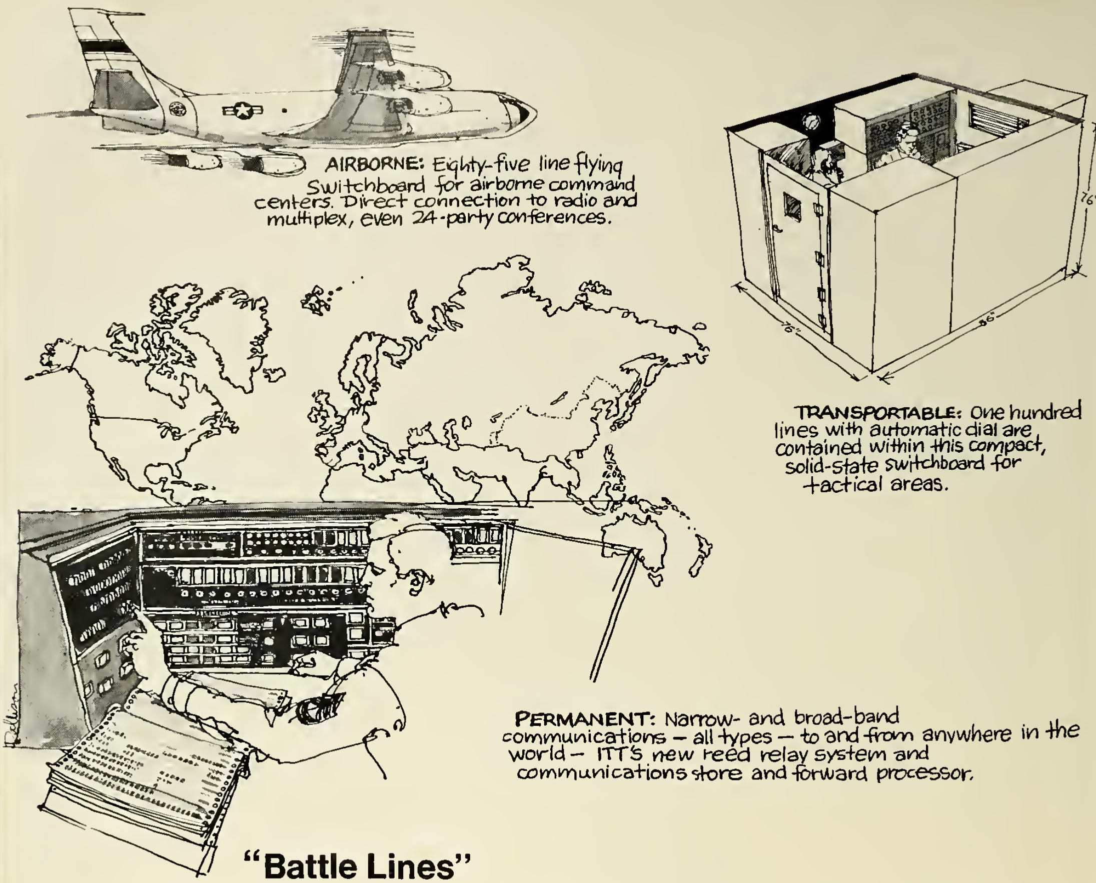
Other awards will be presented at the space club's annual Goddard Memorial Dinner, to be held in Washington, D.C., March 16. Vice President Hubert H. Humphrey will address the dinner.

The Government-industry team responsible for the *Gemini* space flights during 1965 will receive the Nelson P. Jackson award. William S. Beller, M/R senior editor, will present the award, which cites, but is not limited to, the Manned Spacecraft Center, Air Force Systems Command, McDonnell Aircraft Corp., Martin Co., Aerojet-General Corp., General Electric Co., IBM Corp., and Westinghouse Electric Corp.

Charles W. Mathews, *Gemini* program director, will receive the 1966 Astronautics Engineer award for his leadership and management of the *Mercury* and *Gemini* programs.

M/R Editors Accept Neal Award

William S. Beller, M/R senior editor, center, accepts the Jesse H. Neal editorial achievement award for MISSILES AND ROCKETS' Special Report on Oceanology (Sept. 6, 1965). The award was presented to M/R staff members by the American Business Press, Inc., in New York City last month. Shown, left to right, are Friedrich Schonbach, art director; Reed Bundy, managing editor; Beller; James W. Claar, publisher, and John B. Babcock, president of the American Business Press. Unable to attend the presentation luncheon was M/R Editor William J. Coughlin.



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ITT

Radar May Alter Point Defense Plans

Low-cost system for hard sites, coupled with consistent HIBEX successes, could preclude need for more ICBM's in silos

by Michael Getler

AN IMPORTANT BREAKTHROUGH in reducing the cost of large-aperture phased-array radars may pave the way for more serious consideration within the Defense Department of development and installation of a hard-point defense system to protect United States ICBM complexes and command posts.

The system, known as HAPDAR, an acronym for hard-point demonstration array radar, is now undergoing Government acceptance tests at the White Sands Missile Range, N.M., where it has been in operation since October.

The radar, a 30-ft.-dia. planar array, was developed and built by the Sperry Gyroscope Co., Great Neck, N.Y., a division of Sperry Rand Corp., under contract to DOD's Advanced Research Projects Agency.

Overall cost of the program, say ARPA scientists, was "about $3 million," which, they say, is "amazing."

"This is less than half of what we would previously have expected to pay for array radars with substantial capabilities."

How costs cut—Principal innovations that have led to the cost reductions have been use of a single, standard feed for the array rather than using individual transmitters for each antenna element, and development of a passive electronic phase-shifting network, which has allowed the efficient use of relatively inexpensive diodes and removed the need for more conventional delay lines.

The impact of the new radar is directly tied to the substantial progress that has also been made in ARPA's *HIBEX* (*High-acceleration Booster Experiment*) program, in which feasibility of extremely-high-speed interceptor missiles is being explored.

Both programs remain experimental technology efforts, and are not tied to specific weapons development projects at this point. In that respect, HAPDAR, in its current configuration, is not viewed as a prototype radar that would work in conjunction with any future *HIBEX*-type interceptor.

However, both programs were set up as parallel tasks to supply answers to DOD as to the availability of technology for building an effective terminal defense against ballistic missiles at a "modest cost."

If a system can be made to perform effectively, cost then becomes the major determinant as to whether or not it is cheaper for the U.S. to maintain its assured destruction force levels by adding more ICBM's and silos or by defending those already in place.

There is considerable enthusiasm in ARPA regarding the advances made thus far in both programs. Scientists told MISSILES AND ROCKETS "we can lick these two critical problems."

The HAPDAR radar is a multi-function search and track system that can handle multiple targets. The system uses a five-horn monopulse feed system to radiate the honeycomb-type array. A Univac 1218 computer is used to control the diode phase-shifting network and accomplish the rapid scanning and multiple-target beam-switching function required.

Assist from HIBEX—Developments in the *HIBEX* program have shown it possible to accelerate intercepting missiles fast enough so that some of the range and associated power requirements and design complexity can be removed from the radar.

Performance and cost of the radar is "orders of magnitude" less than that required for the multi-function array radar (MAR) being developed for the *Nike-X* area defense system. In the *HIBEX*/HAPDAR project, intercepts would take place much closer to the target, possibly even lower than 20,000 ft., and the target itself is hardened to withstand a nuclear blast.

In the *Nike-X* program, where cities would be protected and accuracy demands are much more stringent, intercept with the *Sprint* high-acceleration missile would take place at much higher levels, probably out to 100,000 ft., officials say.

The HAPDAR radar has been tested at WSMR, using aircraft first to develop pattern profiles, and is now being used against missile targets of opportunity. The radar did not attempt to track the last *HIBEX* launching, which took place in January, but designers say there would be no problem in tracking *HIBEX* and that it is mostly a function of the computer.

Upon completion of acceptance tests by ARPA, Sperry is expected to be funded for an additional year of operation with the radar at WSMR. Scientists say final evaluation of the *HIBEX* series of firings is nearing completion and that there is considerable flight data to support the reliability and validity of controllable very-high-acceleration boosters. The program's success, apparent in very early phases, enabled a reduction in the planned dozen flight tests. Only one flight was unsuccessful, although data was taken partially through the flight sequence.

While there is no follow-on currently planned for HAPDAR, an awareness within the electronics industry that ARPA was interested in pursuing passively shifted array radars and a knowledge of the Sperry project has touched off considerable activity. ARPA scientists expect that further state-of-the-art advances and cost reductions will emerge.

Emphasis in the interceptor area will now shift to the so-called end-game portion, which involves final correction from boost-phase guidance to target intercept. Scientists say a number of guidance and control modes are under study and that a flight-test phase will follow, using *HIBEX* boosters. ■

McDonnell Is Selected For MAW Development

THE ARMY, as anticipated (M/R, Jan. 10, p. 15), has announced selection of McDonnell Aircraft Corp. to develop the new *Medium Assault Weapon (MAW)*. The St. Louis firm has received a $485,000 contract to proceed with development.

MAW will be used defensively against tanks, armored vehicles or other hard targets, and offensively as an infantry assault weapon. The missile, designed to be handled by a single soldier, is expected to weigh about 30 lbs. and have a maximum range of 1,000-1,500 yards.

The system, which will complement the heavier *TOW* assault missile already under development, will use wire guidance. Tracking information will be derived with a launcher-mounted optical sight.

Navy To Strengthen Central Authority

Reorganization effective May 1 is designed to enhance power of CNO; new stress to be given weapon development and procurement

by Robert W. Niblock

A MAJOR REORGANIZATION of the Navy's management structure which, if approved by Congress, will become effective May 1, was announced this week by Secretary of the Navy Paul H. Nitze.

The Navy reorganization follows the lines of new Dept. of Defense management techniques laid down by Secretary of Defense Robert S. McNamara when he became Pentagon boss in 1961.

All but two of the Navy's traditional bureaus are now eliminated, the authority of the Chief of Naval Operations is strengthened and the Navy Material Command has been reorganized into six functional commands directly under CNO.

While the Army and the Air Force reorganized a few years ago, Nitze said at a news conference the Navy was tougher to "restructure," especially because of its virtually autonomous bureaus. The creation of the Naval Material Support Establishment in July, 1963, did give the Chief of Navy Material command over the bureaus. However, under this arrangement, the four affected bureaus—Bureau of Weapons, Bureau of Yards and Docks, Bureau of Supplies and Accounts and Bureau of Ships—reported directly to the Secretary of the Navy, not to the CNO.

Six new systems commands will assume the tasks previously handled by the bureaus. They will be known as the Air Systems Command, Ship Systems Command, Electronic Systems Command, Ordnance Systems Command, Supply Systems Command and Facilities Engineering Command.

Although their titles are changed, BuSandA and BuDocks will have the same responsibilities under their new titles, Supply Systems Command and Facilities Engineering Command respectively. BuShips will be split into the Ship Systems and Electronic Systems Command and BuWeps will be separated into Air Systems and Ordnance Systems Commands.

New appointments—The commanders of the present bureaus will take over their equivalent systems commands and DOD will sponsor legislation to accord them the same rank, pay and retirement privileges currently provided to bureau chiefs.

Two new appointments have been made: Rear Adm. Joseph E. Rice, Commander, Naval Shore Electronics Engineering Center, will become the Electronic Systems Commander and Rear Adm. Arthur R. Gralla, BuWeps Deputy, will head the Ordnance Systems Command. The four other commanders are Rear Admirals Allen M. Shinn, Air Systems; Edward J. Fahy, Ship Systems; Herschel J. Goldberg, Supply Systems; and Alexander C. Husband, Facilities Engineering. All are under Vice Adm. Ignatius J. Galantin, Chief of Navy Material.

CNO McDonald—to get stronger hand.

The total number of personnel to be assigned to the six components is 375,800, the same manpower in the four existing bureaus. Largest component in terms of manpower will be the Air Systems Command with 167,600 people.

The Bureau of Naval Personnel and Bureau of Medicine and Surgery will retain their titles and functions, reporting directly to the Secretary of the Navy.

Accompanying Nitze to Monday's news conference were Adm. David L. McDonald, Chief of Naval Operations; Gen. Wallace M. Greene, Jr., Commandant of the Marine Corps, and Galantin.

Goals listed by Nitze for the reorganization were: a firm and strengthened approach to weapons development and acquisition; increased management strength of the functional organizations under the Chief of Navy Material; more emphasis on ordnance in electronics; centralized and improved coordination of RDT&E management; more emphasis on logistics support and maintenance weapons systems, and increased efficiency and economy through exploitation of opportunities for consolidation of common services.

Responsibilities as outlined at the conference for the respective systems commands are as follows:

Air Systems—Responsible for aircraft, air-launched weapons systems, airborne electronics, air-launched underwater sound systems, airborne pyrotechnics. astronautics, airborne minesweeping equipment, aircraft drone and target systems, land-based targets for air weapons, air systems special support equipment, photographic and meteorological equipment and active and reserve air systems maintenance support.

Ship Systems—Responsible for ship systems design and integration, ship construction, ship propulsion, ship auxiliary power generating and distribution systems, navigational equipment, ship habitability and environmental control, ship-mounted sonar, ship-mounted search radar, antenna design and integration, NTDS, and shipborne mine-sweeping equipment.

Electronic Systems—Shore electronics, shipboard electronic equipment, material support of air systems command for navigation aids, air traffic control and meteorology, SATCOM and material support of SPASUR, shore-based strategic data systems, data link systems external to ships and aircraft, Radiac equipment, general-purpose test equipment and common components, and technical authority for electronic standards and compatibility.

Ordnance Systems—Shipboard weapons systems, including functional responsibility for fire control radar, fire control equipment, weapons direction equipment, weapons direction equipment switchboards, launchers and expendables, ship-mounted sonar including programming and control of systems performance, air-launched underwater weapons, explosive safety, seaborne targets, and research and exploratory development of explosives. ■

Agena Ready for Gemini 8 Rendezvous

Target vehicle clears test firings at AEDC; space agency gives further outline of flight plans for Armstrong and Scott

by Hal Taylor

NASA HAS COMPLETED a series of test firings of the *Agena* target vehicle and has certified it ready for the *Gemini 8* space flight this week.

The test firings at the Air Force's Arnold Engineering Development Center, Tullahoma, Tenn., included 14 Phase 1 ignition tests and 14 Phase 2 mission simulation tests.

The longest firing was 180 sec., which equals the engine burn needed to place the *Agena* in the proper orbit for a rendezvous with *Gemini.*

Total length of the engine firings—which were completed on March 7—was 940 sec. A number of malfunction firings will be made after this week's flight is completed.

In other manned space flight developments, the space agency announced further details of the *Gemini 8* mission, scheduled for no earlier than March 15, and reported that the first *Apollo/Saturn IB* mission on Feb. 26 achieved all flight objectives.

Recent test firing of Bell Aerosystems engine for Agena target vehicle.

GTA-8—*Gemini 8* is to begin with the launch of the *Agena* target vehicle by an *Atlas* booster at 10 a.m. EST. It will be placed in a 185-n.mi. circular orbit.

Launch of the *Gemini* spacecraft with its astronaut crew of command pilot Neil Armstrong and pilot David Scott will follow 100 minutes later at 11:40 a.m. EST. It will be placed in a 100 x 168 mi. eliptical orbit by its *Titan II* booster.

The rendezvous of the *Gemini 8* spacecraft with the *Agena* will take place in the fourth revolution, some 5 and ½ hours after liftoff. The first of four attempts to dock with the *Agena* will then be made.

Later Scott will leave the spacecraft and make a space walk which will last over two hours. The flight is expected to last almost three days, with re-entry and impact planned for the west Atlantic after the 45th revolution.

(For more details of the mission, see M/R, March 7, p. 15.)

Feb. 26 success—In discussing *Apollo/1B* flight results, NASA said the Command Module was recovered with no evident structural damage. There was no significant damage to the albative heat shield other than the expected charring. The surface was smooth and no excessive erosion was noted. The windows were in good shape, although one was fogged, and the interior was essentially dry.

After launch at 11:12 a.m. EST, the first stage of the *Saturn IB* performance was nominal. The second, SIV-B, stage burned for 10 seconds longer than expected. The longer burning time was attributed to actual average thrust being about 2% below that predicted. NASA said, however, that both thrust and time deviation were within expected tolerances. The guidance automatically compensated for the lower thrust by extending burning time to achieve the desired results.

NASA also said the guidance and control system performed well, with both the SI-B and SIV-B trajectory completely normal. The quality of data received at ground stations was good. Very few losses occurred in the 1,300 measurements sent back to Earth.

One of two cameras on board the first stage, which was recovered by the Air Force, reportedly has excellent coverage of stage separation and SIV-B ignition.

A below-normal performance of the Service Module's main propulsion engine resulted in an re-entry speed some 500 mph less than the 18,500 mph which was expected. Re-entry speed was adequate, however, to evaluate the performance of the spacecraft heat shield for Earth-orbital missions.

The Service Module engine burned normally at the start of the first firing and then a slight decrease was noted. Pressures were back to normal at the end of the second firing of the engine. A careful study of data is expected to provide the cause of the pressure drop.

The Earth-landing system functioned as planned. After impact, however, one of the main two parachute disconnects failed to work and the parachutes remained attached to the spacecraft until recovery personnel cut them free. NASA said it would examine the parachute disconnect to discover the cause of the misfire.

Helicopters and swimmers were at the spacecraft about 33 minutes after splashdown. It was retrieved by the USS Boxer at 2:13 p.m. EST, about 3 hrs. after liftoff.

The spacecraft will be flown to Downey, Calif., for detailed inspection by NASA and North American Aviation, Inc.

(For further details of the *Saturn-IB/Apollo* mission, see p. 22.) ■

Oceanology Called 'Growth Stock' Area

Navy expert warns that payoffs for aerospace firms may be decade away; a report from Third Space Congress of Canaveral Council

by John Rhea

Cocoa Beach, Fla.—Oceanology should be looked upon by aerospace companies as a growth stock, not a blue chip, according to Capt. T. K. Treadwell, deputy commander for oceanography of the U.S. Naval Oceanographic Office.

He spoke at the Third Space Congress, sponsored here by the Canaveral Council of Technical Societies.

Capt. Treadwell warned aerospace contractors: Don't expect a quick payoff and don't jump into the oceanology field without thoroughly examining the field to weed out unprofitable areas. He said the goal of making a quick profit through diversification into undersea work will not be realized in this decade.

The oceanologist admitted that he was first dubious about the use of spacecraft for oceanographic research, but has since become enthusiastic. Gathering data from under the sea is difficult, he said, because of outmoded research vehicles and politically and geographically hostile areas.

Satellite potential—Satellites may be able to handle the job. In addition, they give a comprehensive view of the Earth's ocean-atmosphere system, necessary to understand the "giant heat engine" responsible for the Earth's weather.

Treadwell said he also believes such techniques as real-time data processing, telemetry and data display, all old hat to the space field, can be readily adapted by oceanographers.

Meryl C. Burns, director of market analysis at Radiation Inc., sounded a similar warning. He said the oceanology market consists of seven segments, three of which—mining and oil recovery, mineral extraction from sea water and recreation and environmental control—are outside the current scope of the aerospace industry.

But he also listed four other segments. The first, defense, is a natural for aerospace firms to enter, he said. They have the technical competence, management skills, facilities and the marketing relationship with the Government. Profits will be adequate, he said, and the risk of failure small.

Next is the so-called scientific market. It is small, he said, but offers a solid scientific base for future progress. He advised spending company funds here, but warned that profits were probably five years away.

Other segments are not particularly attractive to aerospace firms, Burns said. These include fishing and fish farming, and transportation, including shipping.

Advice for aerospace firms—J. H. Clotworthy, vice president of Westinghouse Electric Corp. and head of the company's Undersea Division and the Defense and Space Center in Baltimore, listed five immediate goals to orient the aerospace industry to oceanology.

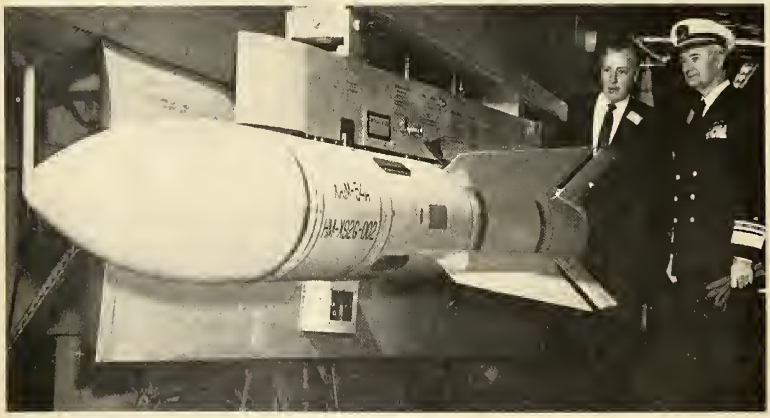
These are: 1) avoid the surface of the ocean, and concentrate instead on undersea work where aerospace technology can be used; 2) if surface work is necessary, cancel effects of turbulence by using a vertical structure with enough mass below the surface to provide stabilization; 3) put benchmarks on the sea's bottom, not on the surface; 4) avoid the use of lines, since they either part or foul when most needed; 5) design research vehicles with the least resistance to water flow for real utility.

He also set forth five philosophical principles for oceanology: 1) establish a unique underwater industry, rather than try to transfer Earth-based technology to the depths of the sea; 2) make industry needs known to universities which will develop scientific and engineering personnel; 3) set up a comprehensive law of the sea, which will go beyond present agreements to include future contested land in the middle of the oceans and at the mouths of inland bodies of water; 4) make man the focal point of any exploration; 5) promote public awareness of the value of oceanology.

Astronaut-aquanaut Scott Carpenter, who also spoke at the conclave, said a drug is being developed now to combat oxygen toxicity in the Navy's deep-submergence systems project (DSSP). As a reverse to the sharing of space technology with undersea work, the drug shows promise for spacecraft use, Carpenter said.

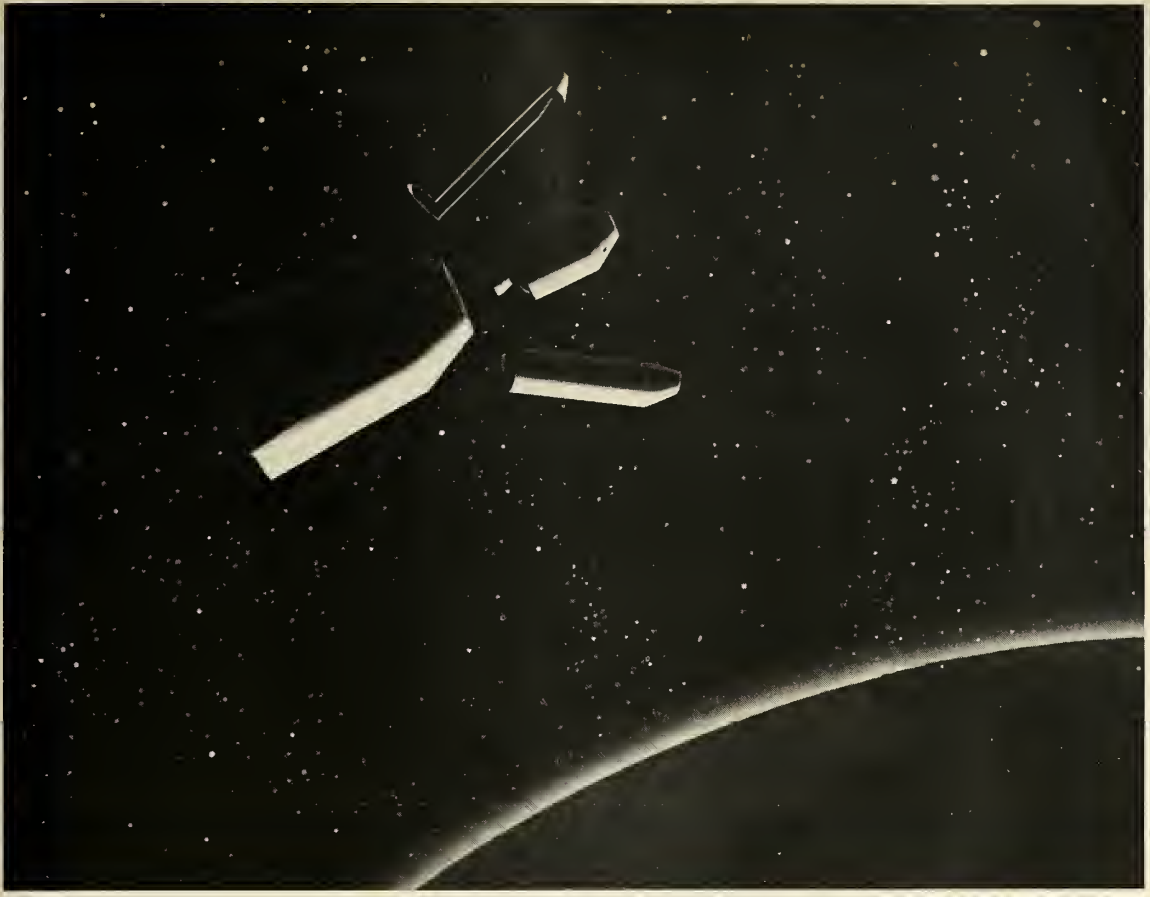
In addition, Carpenter said, studies are under way on the use of hydrogen as an inert gas for use with breathing oxygen at great depths. The usually explosive element may be controllable for the special-purpose use.

Oceanology sessions of the Third Space Congress drew such attention that closed-circuit television had to be used between the overflowing meeting room and other rooms of the motel at which the sessions were held. ■



First Photo of Navy's Phoenix Missile

Test model of Navy's Phoenix air-to-air missile is inspected by Vice Adm. I. J. Galantin, right, chief of naval material, and M. A. Livesay of Hughes Aircraft Co. Hughes is prime contractor for the missile, being developed for the F-111B aircraft. This is the first photo released of Phoenix. Rocketdyne Div., North American Aviation, Inc., is propulsion subcontractor to NAA for the Phoenix program.



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No Problems for Next Saturn-Apollo

First study of data from Feb. 26 Saturn IB-Apollo mission indicated all test objectives were met; run-down by Shea, Lunney

by Jinx Mercer

HOUSTON—Results of the first unmanned *Apollo* flight from Cape Kennedy aboard *Saturn IB* on Feb. 26 indicate that only minor "cleaning up" is needed prior to the *Apollo-Saturn 202* mission this summer.

Preliminary analysis of telemetered data and on-board camera film, and inspection of the re-entry module after recovery has revealed that the Feb. 26 flight "met all test objectives," NASA officials said here last week.

Dr. Joseph P. Shea, *Apollo* spacecraft program manager, reported that data stripped from on-board telemetry tapes collecting heat-shield measurements show that a surface temperature of 4,050°F was reached during maximum re-entry heating—10% below what was expected. Maximum heat rate imposed on the spacecraft by its ballistic trajectory was 186 Btu/ft.^{2}/sec., or 7% less than anticipated.

Chamber pressure drop—NASA officials have concluded that the slightly reduced re-entry speed of the Command Module—some 500 mph less than the programmed 18,500 mph—was caused by the drop in Service Propulsion System (SPS) engine chamber pressure during the two burns to accelerate the Command Module through the atmosphere for higher-than-normal orbital re-entry heating rates.

Chamber pressure, normally about 100 psi, began to decay gradually after the first 80 sec. of the 180-sec. burn, leveling out to "around 70 psi," Shea said. Engine-mounted accelerometers indicated that the engine was burning smoothly.

Shea said telemetry showed a simultaneous decay in the oxidizer inlet pressure measured downstream of the tanks, but that the regulator for helium, which is used to pressurize the oxidizer, was at the nominal 195-psi pressure.

After shutdown of the first SPS burn, which was followed by a 10-sec. coasting period, the SPS engine was re-ignited and for the first 5 sec. burned "abnormally," Shea continued.

"At about 5 sec., the chamber pressure dropped to a low of 10 psi—almost off—then recovered sharply and stabilized at 95 psi."

Shea concluded that the "problem" apparently was not in the engine or the engine chamber but "in the bottom of the (oxidizer) tank" or where the oxidizer enters the engine.

Visual inspection of the Command Module showed that ablation was heavy on the aft portion of the heat shield, which was "expected." Heavy charring was reported along the conical portion of the spacecraft "from 20 degs. around to 150 degs. (aft of the horizontal axis through the spacecraft)." VHF scimitar antennas which protrude on both the wind and lee sides of the Command Module during re-entry were not excessively charred, the NASA official reported.

One of two pyrotechnic cutting devices designed to sever the parachutes from the Command Module after splashdown failed to operate, and only one end of the bridle was severed, Shea said. However, both the "pyro" and the sequencer were recovered for closer inspection.

Difficulties—Glynn S. Lunney, *AS-201* flight director in Houston's Mission Control Center, reported a few "plus-time" problems:

—A temporary loss of power at Cape Kennedy knocked out the MCC's impact predict computer for several minutes—long enough to lose its data. Flight controllers picked up the track from telemetry coming out of the *Saturn* guidance system directly into the MCC and several minutes later had a radar track on MCC impact point plotboards based on Bermuda tracking data.

—A 17-deg. "drift" in an instrument gyro placed on board to monitor the SPS engine burn was noted during the "max Q" portion of powered flight. Lunney said they calibrated the deviation by cross-checking with the launch vehicle's platform and relayed the anomaly to flight controllers aboard the Rose Knot Victor tracking ship who would be monitoring the Service Module burn when the vehicle moved into range.

—Impact occurred 43 n. mi. uprange at a point 8 deg., 11 min. south latitude and 11 deg., 9 min. west longitude. The "miss" was attributed to the re-entry module's achieving slightly less lift than anticipated in L/D predictions, Lunney said. The Command Module was retrieved from the sea about one minute before sundown by the aircraft carrier USS Boxer.

Booster performance excellent—Col. William Teir, deputy manager for the *Saturn IB* launch vehicle at Marshall Space Flight Center, reported only minor deviations in the booster's performance.

Velocity cutoff of the S-IB first-stage outboard engines was 26 fps faster than predicted but "within tolerance." The inboard engines cut off at 141.4 sec., or 0.9 sec. late; outboard engines (by propellant depletion sensors) terminated at 146.9 sec., or 0.3 sec. after the predicted time.

The S-IVB stage ignited at 149.3 sec., in proper sequence with the first-stage cutoff. Separation was "clean." Second-stage engine cutoff (SSECO) occurred at 602.9 sec. and the longer burning time of approximately 9.8 sec. was attributed to average engine thrust being 2% less than predicted calculations, Teir explained.

Velocity at SSECO was 21,439 fps, or 1 fps less than predicted. The spacecraft separation signal was given at 843 sec., or 240.2 sec. after SSECO, Teir pointed out. Total velocity at spacecraft separation was 3.9 sec. faster than predicted. "We feel this is due to tail-off burn of the S-IVB stage with a slight additional thrust, probably from venting," Teir said. Altitude at separation was 234.8 n. mi., or 0.6 n. mi. higher than predicted.

The S-IVB stage during its powered phase maintained unusually stable attitude, Teir revealed. In-flight stabilization is provided by main-engine gimbaling for pitch and yaw control and by two auxiliary propulsion system (APS) sets of thrusters for roll control. After S-IVB engine cutoff, the APS takes over pitch and yaw attitude control. Propellant consumption, Teir explained, was much lower than expected. The APS used only one-third of total propellant—50% less than anticipated.

Both on-board cameras located in the front of the S-IB stage to film the separation sequence ran into "parachute troubles," Teir said, but one was recovered intact. On-board tape recorders operated without problems. "We lost only 12 pieces of data out of 1,200-1,300 TM measurements." ■

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ASTROLOG

Current Status of U.S. Missile and Space Programs

satellites and spacecraft

ADVANCED ORBITING SOLAR OBSERVATORY (NASA)

Republic, prime. DESCRIPTION: 1,250-lb. spacecraft to make detailed measurements of Sun's radiation; greater pointing accuracy (5 arc sec) than OSO; launch vehicle, THRUST AUGMENTED THOR-AGENA. STATUS: Telescope experiment may be added to APOLLO Applications.

APPLICATIONS TECHNOLOGY SATELLITE (NASA)

Hughes, spacecraft integration; GE, gradient stabilization. DESCRIPTION: Five-satellite program to test communication and meteorological equipment in spin-stabilized and gravity-gradient spacecraft in medium and synchronous orbits; test bed for gravity gradient stabilization, ion engine attitude control, photographic, and mass data collection experiments; weight, first spacecraft, 1,550 lbs., second, 782 lbs., others undetermined; launch vehicle, ATLAS-AGENA D. STATUS: Development; first flight scheduled for late 1966.

APOLLO (NASA)

North American, Command & Service modules, systems integration; Grumman, Lunar Excursion Module (LEM); MIT, guidance development; AC Spark Plug, guidance prime; Collins Radio, telecommunications; Honeywell, stabilization & control; AiResearch, environmental control; Northrop-Ventura, parachute recovery; Lockheed Propulsion Co., escape tower rocket; Marquardt, reaction controls; IBM, realtime computer complex; Westinghouse, power conversion equipment. Lunar Excursion Module, prime, Grumman; descent engine, TRW Systems Group; ascent engine Bell Aerosystems; environmental control, Hamilton Standard; reaction control thruster, Marquardt; guidance, MIT; radar & communications instruments, RCA; TMC, telemetry, Radiation Inc.; fuel cell, Pratt & Whitney; external visual display, Farand Optical; GE, acceptance checkout reliability; rendezvous optical system, Hughes. DESCRIPTION: Three-man spacecraft for Earth-orbital, lunar-orbital and lunar-landing missions. Boosters: SATURN I and SATURN IB for Earth orbits; SATURN V for lunar rendezvous and landing missions; 3-modular spacecraft: Command Module Weight, 5-1/2 tons; Service Module, 25 tons; Lunar Excursion Module, 15 tons; total weight, 95,000 lbs. STATUS: First of a series of unmanned orbital tests began with a boilerplate model launch of SA-7, Sept. 18, 1964; first flight-rated spacecraft launched successfully Feb. 23, 1966; lunar landing will be made in the 1968-69 period; first manned orbital flight due last half of 1966.

APOLLO APPLICATIONS (NASA)

No contractors named. DESCRIPTION: APOLLO spacecraft would be modified to provide extended life support and battery capability; two tanks would be removed from the Service Module propulsion section to provide room for additional consumable supplies; ascent stage of Lunar Excursion Module for extended operations in lunar orbit and on the lunar surface; many experimental payloads have been proposed, including orbiting telescopes, survey, mapping communications and many others. Boosters: SATURN IB and SATURN V. STATUS: Two or more firms to be selected for systems definition by May 1, 1966; about 20 flights are planned beginning in late 1968.

ATHENA (Air Force)

Atlantic Research, prime; Honeywell, guidance. DESCRIPTION: 17,500-lb. four-stage re-entry vehicle, attains apogees from 600,000 to 1,000,000 ft.; last two stages drive vehicle and payload earthward at near-ICBM velocities; major diameter, 32 in.; velocity package diameter, 28 in.; length, 51 ft. First-stage engine, Castor XM33 (Thiokol); second stage, either X261 (Thiokol) or X259 (Naval Propellant Plant); third stage, 30KS8000 (Aerojet); fourth stage, Ranger Retro BE3, Hercules. STATUS: Engaged in sub-scale testing of advanced re-entry concepts in ABRES program; AF will buy 36 more vehicles for some $14 million which will carry program far beyond initial 77-flight plan; advanced version proposed to AF for 450-lb. payload.

BIOSATELLITE (NASA)

GE, prime. DESCRIPTION: 1,000-lb. satellites to test effects of space environment on plants, animals (primates) and other biological specimens; launch vehicle, THRUST-AUGMENTED DELTA. STATUS: Six flight models to be built; first flight in mid-1966; others to follow at three-month intervals; 14 experiments selected for first flight.

COMSAT CORP. SATELLITE PROGRAM

TRW picked for contract negotiations for advanced worldwide satellite system; spacecraft would have capacity of some 1,200 two-way voice circuits and be launched into synchronous orbits; delivery of first six satellites 24 months after signing; launch vehicle not yet selected; Sylvania Electric Products to provide antenna systems at Washington State, Hawaii Earth stations, with delivery to start May 1, 1966; corporation also working on system for use with APOLLO program and commercial communications; Hughes aircraft awarded contract for four synchronous satellites, with two to be orbited probably in August; Page Communications Engineers to provide transportable Earth stations; Comsat also studying bids from 7 firms for multipurpose synchronous satellite; EARLY BIRD, 85-lb. experimental/operational satellite built by Hughes, launched April 6 and now in synchronous orbit over Atlantic, transmitting between U. S. and Europe.

DISCOVERER (Air Force Program 622A)

Lockheed, prime; GE, re-entry vehicle. DESCRIPTION: THOR-AGENA and ATLAS-AGENA launchings of stabilized satellites; main purpose is to test techniques and components for military space systems. STATUS: All data on program classified as part of DOD information policy; however, indications are that program has been cut back or ended as more economical vehicles have come into use.

ECHO (NASA)

Langley Research Center, prime. DESCRIPTION: ECHO I ,135-ft. inflatable sphere in 700- to 805-mi. orbit; passive communication satellite; booster, THOR for ballistic tests; THOR-AGENA for orbital. STATUS: Program complete; ECHO I in orbit since Aug. 12, 1960; two ballistic shots in 1962 unsuccessful; ECHO II launched from Vandenberg Jan. 27, 1964; U.S.-USSR conducting experiments using ECHO.

ESSA (Environmental Science Services Administration)

RCA, prime; DESCRIPTION: 285-lb. operational weather satellite launched into polar orbit by the THRUST-AUGMENTED DELTA; ESSA based on the TIROS wheel configuration; future satellites will have the Advanced Vidicon Camera System (AVCS) in addition to the Automatic Picture Transmission (APT) system. STATUS: ESSA I launched on Feb. 3, 1966, and ESSA II launched on Feb. 28, 1966, into polar orbit to form the first operational weather satellite system; plans call for keeping two satellites—one with AVCS and one with APT—in orbit at all times for global weather coverage.

GEMINI (NASA)

McDonnell, prime; Rocketdyne, spacecraft propulsion; General Electric, fuel cell; IBM, guidance system integration and computer; Honeywell, guidance; Westinghouse, rendezvous radar; AiResearch, environment. DESCRIPTION: Bigger and heavier MERCURY-type capsule to carry two men for up to two weeks; TITAN II used as booster; ATLAS-launched AGENA will be used for rendezvous missions; 15 spacecraft will be produced. STATUS: Development; 12 flights planned; will be used to determine feasibility of rendezvous for lunar mission and long-duration manned flight; first unmanned flight, April, 1964, successful; second unmanned orbital flight, January, 1965, successful; first manned flight successful March 23; second flight successful, June 3-7, 1965, including first extravehicular activity; eight-day GEMINI 5 flight, Aug. 21-29; successful; GT-7 flight, launched Dec. 4, set world record for manned spaceflight duration (14 days); GT-6 launched Dec. 15 after two previous attempts scrubbed; first space rendezvous achieved Dec. 15 during 14-day GEMINI 7 flight when GEMINI 6 on one-day mission came within one foot of sister craft; GEMINI 8 scheduled March 15; four more flights planned in 1966; AF participating in program, and will modify GEMINI capsule for MOL.

GEOS (NASA)
Applied Physics Laboratory, prime. DESCRIPTION: 350-lb. geodetic satellite (similar to ANNA) to carry flashing-light beacons, electronic beacons and optical and radar reflectors; launch vehicle, IMPROVED DELTA; 700-900-mi. orbit at a 59-degree inclination. STATUS: First flight launched successfully Nov. 6, 1965; PAGEOS passive satellite developed by Langley Research Center will also be launched first half of 1966.

HYPERSONIC RESEARCH VEHICLE (Air Force, NASA)
No contractors announced. DESCRIPTION: Manned hypersonic spacecraft capable of Earth-to-orbit-and-return; turbofan, Mach 0-3; ramjet, Mach 3-8 or 10 (oxygen collected and liquefied during this cycle); Mach 8-10 orbital speeds, LH_2-LOX rocket. STATUS: Joint NASA-AF research program approved; NASA funding \$5 million in FY '66; AF has advanced technology program in six pertinent areas (mostly engine developments) in FY '65. GE, Pratt & Whitney and Marquardt selected for conceptual and preliminary design of a research engine; engine flight test planned for early 1968.

ICBM ALARM (Formerly MIDAS) (Air Force Program 239A)
Lockheed, prime; Aerojet, IR detector system. DESCRIPTION: Early-warning random-orbit satellite; detect ICBM launchings by IR; two flights conducted in 1963 detected solid and liquid missile launches; satellites are launched piggy-back on various AF boosters. STATUS: Development; no decision on deployment; reportedly competing with over-the-horizon radar; Air Force is currently studying requirements for a new, multi-function satellite, combining the functions of MIDAS and SAMOS; new funding in FY '67 for space-based early warning systems.

INTERPLANETARY MONITORING PLATFORM (NASA)
Goddard Space Flight Center, prime; Martin Co. developing nuclear power unit; BTL/Univac, guidance. DESCRIPTION: 131 to 181-lb. satellite launched into cislunar-space orbit with an apogee of more than 100,000 mi.; will measure radiation and solar flare hazards in advance of Project APOLLO; launched by DELTA and THRUST-AUGMENTED DELTA boosters from AMR. STATUS: IMP-I launched in December, 1963; IMP-II launched Oct. 3, 1965; five more satellites are planned, two to be placed in lunar orbit; later flights will use a nuclear power unit as replacement for solar cells; designation, IMP-I is EXPLORER XVIII; IMP-II is EXPLORER XXI.

ISIS (Canada, U.S.)
Canadian Defense Research Board, satellite; NASA, launch vehicle. DESCRIPTION: Three-satellite follow-on program to ALOUETTE to continue ionospheric studies. STATUS: Design of ISIS A begun in 1964 with launch planned in 1967; B and C to be launched in 1968, 1969; launch vehicle, THOR-AGENA.

LES (Air Force)
M. I. T. Lincoln Laboratory, prime; consulting support, TRW Systems Group. DESCRIPTION: a series of Lincoln Experimental Satellites carried as TITAN III-A and III-C "bonus" payloads to test military comsat devices and techniques. STATUS: First launch Feb. 11 failed; second, May 6, achieved orbit; LES-3 and 4 launched Dec. 21 are operating but in wrong orbit because of TITAN control failure.

LUNAR LOGISTICS SYSTEM (NASA)
Studies have been conducted by Grumman, TRW Systems Group and Northrop. DESCRIPTION: Spacecraft to carry support payloads to the Moon. Two designs under study—LEM truck with 7,000-lb. payload and logistics spacecraft with 25,000 to 30,000-lb. payload; booster, SATURN V. STATUS: Program definition of the LEM truck planned in FY '67; program would cost about \$1 billion; first step will be to extend lunar stay-time up to two weeks.

LUNAR ORBITER (NASA)
Boeing, prime; RCA, power and communications; Eastman Kodak, cameras; Marquardt, maneuvering engine. DESCRIPTION: 800-lb. spacecraft launched by ATLAS-AGENA will orbit Moon, taking pictures of lunar surface; radioactive and geodetic measurements will also be taken. STATUS: Five flights scheduled beginning in mid-1966.

MANNED ORBITING LABORATORY (Air Force)
Douglas Aircraft Co., prime; GE, on-board experiments; Aerospace Corp., technical management. DESCRIPTION: Two-man spacecraft to establish military usefulness of man in space; booster, TITAN III-C; GEMINI-X capsule atop 10-ft.-dia., 41-ft.-long canister lab; total weight about 25,000 lbs., orbit below 350 mi.; flights of 30 days in shirt-sleeve environment planned. STATUS: Six-launch program now planned; 30-day missions; 60-90 day missions under study; \$159 million in FY '67 funding; unmanned Gemini canister launch, late 1966 or 1967; manned GEMINI canister launch, 1968; rendezvous and ferry capability possible; Honeywell and Collins Radio reported winners of attitude control and communications subsystems; full-scale hardware development this summer following completion of revised system definition studies.

MARINER (NASA)
Jet Propulsion Laboratory, prime. DESCRIPTION: 570-lb. unmanned spacecraft for early interplanetary missions to vicinity of Mars and Venus; boosted by ATLAS-AGENA. STATUS: First scheduled Venus fly-by, August, 1962, unsuccessful after booster failure; second passed within 21,594 mi. of Venus, Dec. 14; two Mars fly-by spacecraft launched in November, 1964; first on Nov. 5 failed due to shroud malfunction; MARINER IV launched Nov. 28, flew by Mars July 14, 1965, and transmitted the first closeup photos of the planet; MARINER flight to Venus in mid-1967, and two flights to Mars in 1969 are planned.

MILITARY COMMUNICATIONS SATELLITE
Aerospace Corp., systems engineering & technical direction; Philco, prime. DESCRIPTION: Multiple-launch, random, active repeater comsat; 24 satellites launched in groups of 8 satellites in 18,300-n.mi. polar orbits; weight about 100 lbs.; TITAN III-C booster. STATUS: Full-scale development as an R&D and "interim" operational system; first launch late spring; DCA has contracted industry studies on a longer-lived Advanced Communication Satellite system; operational status planned in 1969; tactical system also likely.

NATIONAL ORBITING SPACE STATION (NASA, Air Force)
Many studies awarded. DESCRIPTION: Manned space station with orbital lifetime of one to five years for testing components and techniques in the space environment; weight ranges under study vary from 15,000-20,000 up to 200,000 lbs. STATUS: Decision not expected for two to four years. MANNED ORBITING RESEARCH LABORATORY and LARGE ORBITING RESEARCH LABORATORY being considered.

NIMBUS (NASA)
Goddard Space Flight Center, prime; GE, integration and testing; RCA, vidicon cameras. DESCRIPTION: 900-1,100-lb. second-generation weather satellite; Earth-stabilized polar orbiting; TV cameras and IR scanners in payload; THRUST-AUGMENTED THOR-AGENA B booster. STATUS: First launching successful Aug. 28, 1964; picture & IR quality good in spite of satellite's elliptical orbit; satellite quit transmitting Sept. 23, 1965; second scheduled in 1966, third in 1967 and fourth in 1968-69.

NUCLEAR DETECTION SATELLITES (Formerly Vela) (ARPA)
TRW Systems Group, prime; Los Alamos Scientific Lab/Aerospace Corp., payload. DESCRIPTION: 20-sided, 485-lb. satellite for detection of nuclear explosions in space; 50,000-mi. orbit; booster, ATLAS-AGENA; launched in pairs. STATUS: First pair successfully launched in October, 1963; second and third pairs successfully launched July, 1964, and July, 1965; two pairs remain; next aboard TITAN III-C next fall; \$8 million in new funding.

ORBITAL VEHICLE (Air Force)
Series of vehicles under OAR project to orbit small scientific experiments at low cost; first two satellites, OV1-1 and -3, both failed, first due to separation mechanism in flight and second due to launch vehicle explosion; first flight was first known attempt to launch satellite from an ATLAS-ABRES vehicle on ballistic trajectory; OV2-1, developed by Northrop, also fell victim to faulty Titan III-C Transtage Oct. 15; OV2-3 also failed due to Dec. 21 TITAN III-C Control malfunction; space General at work on OV3; OV-1 was successfully launched Oct. 5 aboard an ATLAS-D; program may shift away from using TITAN.

ORBITING ASTRONOMICAL OBSERVATORY (NASA)
Grumman, prime; Westinghouse, ground station, components; GE, stabilization and control; Kollsman, star trackers; IBM, data processor and storage; Hughes and Avco, communications equipment. DESCRIPTION: 3,600-lb. orbiting astronomical satellite to study ultraviolet spectrum from approximately 1,200 Å to 4,000 Å; four major experiments selected; one piggyback; booster, ATLAS-AGENA D. STATUS: First flight March 24, 1966; two more planned.

ORBITING GEOPHYSICAL OBSERVATORY (NASA)
TRW Systems Group, prime; DESCRIPTION: 1,000-lb. satellite with instruments for geophysical measurements; polar (POGO) and eccentric (EGO) shots planned; can carry more than 20 experiments; ATLAS-AGENA, THRUST-AUGMENTED THOR, booster. STATUS: First launch Sept. 4, 1964, partially successful; 16 of 20 experiments working; OGO II launched Oct. 14, 1965 ceased operation Oct. 24, when electrical power failed; third scheduled April 28, 1966; three more planned.

ORBITING SOLAR OBSERVATORY (NASA)
Ball Brothers, prime. DESCRIPTION: OSO I, 458-lb. orbiting solar observatory; OSO II, 535-lbs.; booster, DELTA; S-16 early version; S-17 and S-57 advanced versions. STATUS: First flight March 7, 1962, highly successful; second flight, Feb. 27, 1965, successful. Third satellite, launched Aug. 25, failed to achieve orbit because of premature third-stage ignition, six more flights planned, with next flight in first half of 1966.

PEGASUS (NASA)
Fairchild Hiller, prime. DESCRIPTION: 3,400-lb. meteoroid-detection satellite employing two 50 x 15 ft. extendable detector wings; Earth orbit 300 to 800 mi.; booster, SATURN I. STATUS: Development; will measure size, energy and frequency of meteoroids to evaluate hazards of impact with manned spacecraft; first launch successful in

February; PEGASUS B, May 25, 1965, and PEGASUS C, July 30, 1965, also successful. No more launches planned; formerly known as METEORIOD DETECTION SATELLITE.

PIONEER (NASA)

TRW Systems Group, prime. DESCRIPTION: 130-lb. spin-stabilized solar probe; AUGMENTED DELTA launch vehicle; cylindrical; covered with 10,000 solar cells; four outrigger booms for stabilization; five experiments, 60 to 90-million-mi. communication capability. STATUS: Seven launches in program; first spacecraft launched successfully Dec. 16, 1965; EXTENDED PIONEER under study.

PROJECT SCANNER (NASA)

Honeywell, fabrication and integration; Baird-Atomic, star-mapper telescope; Santa Barbara Research Center, dual radiometers. DESCRIPTION: Unmanned scientific satellite to measure natural radiation gradients of Earth's horizon to determine utility of spacecraft horizon sensors. STATUS: Flights to begin in 1966.

RADIO ASTRONOMY EXPLORER (NASA)

Goddard, prime for first two spacecraft with industry to build remaining four. DESCRIPTION: 270-lb. satellite which will have four 750-ft. extendable antennas to pinpoint radio emissions in space. STATUS: Hardware funding approved in FY '65 & '66 budgets, with first launch by a THRUST-AUGMENTED DELTA in 1967.

SAMOS (Air Force Program 720A)

Lockheed, prime; photo intelligence equipment, Eastman Kodak; capsules, GE; parachute and guidance recovery equipment, Avco and Northrop Ventura. DESCRIPTION: Reconnaissance satellite; formerly SENTRY; R&D model weighs 4,100 lbs. with E-5 capsule (3,000 lbs. with E-6); booster, ATLAS-AGENA; 100-300-mi. circular polar orbit. STATUS: Operational; advanced SAMOS under development; a successor system, capable of changing orbital plane and altitude on command, is apparently being developed; this newer reconnaissance satellite would have up to six recoverable data capsules or cassettes with lifting-body characteristics, permitting data recovery without returning entire satellite to Earth; could be launched by the TITAN III-B booster now under development; FERRET version used for electronic intelligence and communications eavesdropping.

SATAR (Air Force)

General Dynamics, prime. DESCRIPTION: 300-lb. scientific satellite pod-mounted on side of ATLAS booster; length, 55 in.; diameter 27 in.; 200-lb. payload; orbits vary from 500 to 2,000 n. mi.; as re-entry vehicle, gains speeds up to 30,000 fps; guidance, strap-down system with three orthogonally mounted gyros; unstabilized when in orbit. STATUS: Development; seven vehicles being built under present contract; pods of SATAR type have been flown on 44 missions.

SATELLITE INSPECTOR (Air Force PROGRAM 706)

No contractors announced. DESCRIPTION: Satellite inspection system consisting of a spacecraft capable of co-orbital inspection of non-cooperative satellites. STATUS: Re-oriented from unmanned vehicle to manned satellite using GEMINI; conceptual studies under way.

SECOR (Army)

Cubic Corp., prime, transponder and ground stations; ITT Labs, satellite vehicle. DESCRIPTION: 40-lb. geodetic satellite; rectilinear, measuring 9 x 11 x 14 in.; can be carried piggyback on a variety of boosters; frequency, 162-324 mc for geodetic measurements; 54-216 mc for refraction studies. STATUS: Operational SECOR vehicles 1, 3, 2, 4 and 5 now in orbit. launched in order of mention. SECOR 5, launched Aug. 10, 1965, is the only non-rectilinear satellite in the series, being a 20-in. polished sphere; future SECORS will be rectilinear; expanded program at altitudes of 1,800 mi. is being considered.

SERT (NASA)

RCA, prime. DESCRIPTION: Spinning ballistic test vehicle carrying two electric-propulsion engines for environmental tests. STATUS: First flight July 20, 1964, from Wallops Island, Va., carried a Lewis electron bombardment engine and a Hughes contact ionization engine; the Lewis engine worked well while Hughes engine produced no thrust; follow-on flights cancelled since SERT I proved neutralization of an ion-beam in space; SERT III now under study.

START (Air Force)

Award in only one of an expected 10-14 areas has been announced—Martin Co. for work on a vehicle related to the in-house SLV-5; Aerospace Corp., general systems engineering and technical direction. DESCRIPTION: A four-part experimental program, beginning with ASSET, to explore the materials, structures, flight regimes and other areas related to glide atmospheric entry. STATUS: Follow-on phases include PRIME, PILOT, and a high L/D ratio vehicle; PRIME portion to get $16 million in FY '67 for four sub-orbital flights aboard ATLAS to test maneuverable re-entry of data capsules.

SURVEILLANCE CALIBRATION (Navy)

NRL designed and developed satellites for calibrating ground-based systems; 12 satellites launched to date; Latest Aug. 13; five satellites launched aboard single THOR ABLESTAR to check performance of Navy space surveillance system.

SURVEYOR (NASA)

Hughes, prime; Martin, SNAP device. DESCRIPTION: 2,150-lb. spacecraft for soft-landing 100-300 lbs. of instruments on Moon; nine 2,500-lb. spacecraft are also planned; booster, ATLAS-CENTAUR; SNAP nuclear generator optional. STATUS: First Moon flights May, 1966; seven engineering and three operational spacecraft planned.

SYNCOM (NASA)

Hughes, prime. DESCRIPTION: 24-hr.-orbit instantaneous narrow-band, active-repeater communications satellite; 28 in. in dia. and weighs about 63 lbs.; booster, DELTA; capable of accommodating one full duplex radio telephone channel. STATUS: First launch failed, Feb. 14, 1963; satellite believed to be in orbit but contact lost; SYNCOM II launched July 26, 1963, completely successful; third launch Aug. 19, 1964, successful; satellite positioned in stationary orbit over Pacific; DOD has taken over satellites for military traffic.

SMS (Synchronous Meteorological Satellite) (NASA)

Republic, RCA Astro-Electronics, Hughes, study contracts. DESCRIPTION: 24-hr. weather satellite, Earth-stabilized; TV cameras with variable focus; may use SNAP-50 for power; booster may be ATLAS-AGENA or -CENTAUR. STATUS: Studies to continue; development funds not included in FY '66 budget; ATS and TIROS expected to provide major inputs to the program.

TIROS (NASA, Weather Bureau)

RCA, prime. DESCRIPTION: 285-lb. meteorological satellite; TV pictures of cloud cover; IR sensors to gather heat balance data; one TIROS to be tested for effectiveness in highly elliptical orbit (300-3,000 mi.). STATUS: R&D; 10 satellites launched; all successful.

TRANSIT (NAVY)

Applied Physics Laboratory, prime; Martin, SNAP device; Westinghouse, shipboard satellite signal receivers. DESCRIPTION: Navigational satellite; R&D model over 250 lbs.; operational, 50 to 100 lbs.; operational system; four satellites in random, near-circular 600-mi. orbits; SNAP nuclear generator; ABLESTAR, SCOUT boosters. STATUS: Four-satellite system operational since July, 1964; system established for use by POLARIS subs and surface ships; two nuclear-powered (SNAP-9A) satellites launched in 1963; NASA studying commercial system.

TRS (Air Force)

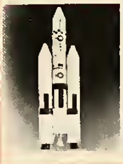
TRW Systems Group, prime. DESCRIPTION: 3-lb. scientific satellite to measure radiation; four-sided, measuring 9 in. on a side. STATUS: Operational; first launched piggyback on DOD payload Oct. 17, 1963.

VOYAGER (NASA)

Either Boeing, GE, or TRW Systems Group will be selected for spacecraft program definition in about a year. DESCRIPTION: Unmanned 7,000-11,000-lb. MARINER follow-on spacecraft bus/lander to orbit Mars and eject a capsule to the surface. STATUS: Development expected to begin in late 1966 or early 1967; lander design to be studied in 1967; program definition funded in FY '66; first launch delayed until 1973; spacecraft to be launched by SATURN V, and will be used to explore other planets through 1970's.

X-15 (NASA, Air Force, Navy)

North American, prime; Thiokol, propulsion; Sperry Gyroscope, inertial flight data system; Honeywell, adaptive flight control electronics. DESCRIPTION: Manned rocket plane capable of 4,000-mph-plus flight at edge of space; single rocket engine develops 57,000 lbs. thrust. STATUS: Powered flights in progress; unofficial records set—altitude 354,200 ft. and speed 4,104 mph; hypersonic propulsion research program should run through 1968; more than 100 flights have been made; ramjet (X-15A2) flights scheduled for 1968.



space vehicles

ABLESTAR (Air Force)

Space-General, prime; Aerojet, propulsion; Space-General/Bell Telephone, guidance. DESCRIPTION: 2,000-lb. upper stage; 9.5 ft. long; 55 in. dia.; radio command guidance; propellants, UDMH/IRFNA; restart capability. STATUS: Used in TRANSIT and other military programs; THOR booster.

ATLAS-AGENA D (Air Force)

General Dynamics/Convair (ATLAS); Lockheed (AGENA); TRW Systems Group, AGENA B; Honeywell, inertial reference. DESCRIPTION: 275,000-lb. booster; payload capability, 5,000 lbs., in 345-mi. orbit, 750 lbs. to escape; length, 102 ft.; base diameter, 10 ft.; liquid propulsion; modified ATLAS D with 360,000-lb. thrust; AGENA B with 15,000-lb. thrust; restart capability. STATUS: Operational; used in RANGER, DISCOVERER, MILITARY COMSAT, MARINER, LUNAR ORBITER, OAO, SAMOS and other programs. ATLAS Standard Launch

Vehicle developed for AF space programs; ATLAS launches from WTR being used in conjunction with ATHENA launches at Green River, Utah, in an effort to develop scaling laws for re-entry bodies (Advanced Ballistic Re-entry Systems program).

AGENA D (Air Force)
Lockheed, prime; Honeywell, guidance; Bell, propulsion. DESCRIPTION: 1,700-lb. upper stage; 25 ft. long; 5 ft. dia.; all-inertial guidance; propellants, UDMH/IRFNA; multiple re-start capability; ATLAS, THOR and AUGMENTED THOR boosters. STATUS: Used in DISCOVERER, SAMOS and other military programs as well as a variety of NASA programs; e.g., MARINER, RANGER, OAO and OGO.

CENTAUR (NASA)
Lewis, program management; General Dynamics/Convair, prime; Pratt & Whitney, propulsion; Honeywell, guidance. DESCRIPTION: High-energy upper stage using a pair of RL-10 LOX/liquid hydrogen engines; 30,000 lbs. total thrust; 30 ft. long; 10 ft. dia.; ATLAS D booster; capable of orbiting 8,500 lbs.; 2,300 lbs. to escape; 1,300 lbs. on planetary flights. STATUS: Development; first flight failed; second launch Nov. 27, 1963, successful; third, June 20, 1964, partially successful; fourth flight Dec. 11, 1964, successful; fifth flight Mar. 2 failed when ATLAS-CENTAUR exploded on pad; CENTAUR 6, Aug. 11, 1965, successful; CENTAUR 8 flight scheduled for first quarter 1966 will be first attempt to restart engine in orbit; first SURVEYOR flight also scheduled for second quarter 1966.

DELTA (NASA)
Douglas, prime; Bell Telephone Labs, guidance; Rocketdyne/Aerojet/Allegany Ballistics Laboratory, propulsion. DESCRIPTION: Successor to THOR-ABLE; upper-stage guidance; three-stage vehicle; 800-lb. payload capability in 100-mi. orbit; THRUST-AUGMENTED DELTA payload capability, 1,500-plus lbs. in 100-mi. orbit; THOR missile comprises first stage. STATUS: Launch vehicle for TIROS, EXPLORER, OSO, BIOS, ECHO; TAD used for SYNCOM & PIONEER; 26 previously on order augmented by AF order for 21 more for NASA; THRUST-AUGMENTED DELTA with three solid motor strap-ons also being used.

LITTLE JOE II (NASA)
General Dynamics/Convair, prime. DESCRIPTION: Solid-propelled vehicle with 800,000-lb. thrust; launch vehicles for APOLLO suborbital flights. STATUS: Three launches; Aug. 28, 1963; May 13, 1964; Dec. 8, 1964, successful; May 19, 1965, launch unsuccessful; last flight Jan. 20, 1966 successful.

POST-SATURN V LAUNCH VEHICLE (NASA)
Under study. DESCRIPTION: No firm concept but will be significant improvement over SATURN V (20-30 million-lb.-thrust first-stage large solid motors, and nuclear upper stage under consideration). STATUS: Study to determine characteristics; operational target date post-1975.

ROVER (NASA, AEC)
Los Alamos Scientific Labs, ROVER prime; Aerojet, NERVA prime; Westinghouse, propulsion. DESCRIPTION: First nuclear rocket; tests of Kiwi, prototype of NERVA engine, under way. STATUS: Kiwi tests completed this year; NERVA tests highly successful; full systems tests of engine now set for fall, 1965—12 months ahead of schedule; development of Phoebus reactor initiated; no flight test program funded at present.

SATURN I (NASA)
Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler Corp.; S-IV, Douglas. DESCRIPTION: Two-stage vehicle for early boilerplate tests of APOLLO and PEGASUS; first stage: eight Rocketdyne H-1 engines; second stage: six Pratt & Whitney RL-10-A3 engines; 22,500 lbs. into 345-mi. orbit. STATUS: Four flight tests of first stage successful; all flights with inert upper stage; first flight with live upper stage successfully launched Jan. 27, putting 37,700 lbs. in low Earth orbit; SA-6 May 28, 1964 and SA-7 Sept. 18, 1964, also successful; SA-9 on Feb. 16 put PEGASUS satellite into orbit; SA-8, May 25, and SA-10, July 30, 1965, also successful, completing R&D program.

SATURN IB (NASA)
Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler; S-IVB stage, Douglas. DESCRIPTION: S-1, eight H-1 engines; S-IVB, one J-2 engine; payload capability, 35,000 lbs. in 105-mi. orbit. STATUS: Development; first flight successful Feb. 23, 1966; boost APOLLO spacecraft boilerplate models, including lunar landing vehicle; first manned flight in APOLLO program set for October, 1966; advanced version able to orbit 30 tons under consideration.

SATURN V (NASA)
Systems engineering, assembly and guidance, Marshall Space Flight Center; S-IC stage, Boeing; S-II, North American; S-IVB, Douglas; F-1 engine, North American; J-2, North American. DESCRIPTION: S-IC, five F-1 engines; S-11, five J-2 engines; S-IVB, J-2 engine; 140-ton payload in 105-mi. orbit; 95,000 lbs. to escape velocity; 30 tons for planetary missions. STATUS: R&D; first flight scheduled for 1967; prime booster for APOLLO missions; will be used to boost orbiting space station.

SCOUT (NASA)
LTV Aerospace Corp., prime; Honeywell, guidance; Aerojet/Thiokol/Allegany Ballistic Laboratory, propulsion. DESCRIPTION: Solid propulsion four-stage satellite launcher; 72 ft. long; 3.3 ft. dia.; 240-lb. payload in 345-mi. orbit; 80 lbs. to escape. STATUS: Operational; used by NASA for EXPLORER and other small payloads; also procured by NASA for Air Force as BLUE SCOUT.

THOR-ABLESTAR (Air Force)
Douglas, prime; Bell Telephone Labs/Univac, guidance; Rocketdyne, first-stage propulsion; Space-General, second; DESCRIPTION: Two-stage vehicle with 181,900 lbs. total thrust; performance, 900 lbs. in 100-n.-mi. orbit; length, 55.9 ft., diameter, 8 ft., weight, 118,200 lbs., height, 79 ft.; guidance, radio command; STATUS: Operational; used in TRANSIT, GEOS and other military programs.

THOR-AGENA D (Air Force and NASA)
No prime; Douglas, THOR frame; Lockheed, AGENA D; Rocketdyne, propulsion. DESCRIPTION: Liquid-propulsion vehicle to put 1,600-lb. payload in 300-mi. orbit; length, 76 ft.; diameter, 8 ft.; launch weight, 123,000 lbs.; 172,000 lbs. thrust; THOR, radio guidance, AGENA, all-inertial. STATUS: Operational; used in AF space program, TELSTAR, Topside Sounder and other NASA programs; NASA has 11 launches scheduled.

THRUST-AUGMENTED DELTA (NASA)
Douglas, prime; Thiokol, solid propulsion. DESCRIPTION: DELTA launch vehicle with three strap-on solids; performance, 1,000 lbs. to Earth orbit; 150 lbs. to escape; propulsion, three XM-33 solid motors producing 55,000 lbs. thrust each. STATUS: Development; to be used for BIOSATELLITE, PIONEER, SYNCOM, TIROS, COMSAT programs; initial flight Aug. 19, 1964, successful.

THRUST-AUGMENTED THOR (Air Force/NASA)
No prime; Rocketdyne and Thiokol, propulsion. DESCRIPTION: THOR-AGENA with 3 strap-on solids; THOR liquid propulsion, 172,000 lbs. of thrust; each strap-on, 55,000 lbs. thrust; performance, 2,500 lbs. in 100-n.mi. orbit. STATUS: Operational; used for NIMBUS, POGO and other payloads too heavy for THOR, but not heavy enough for ATLAS. AF has ordered 22 new "long tank" versions of THOR from Douglas to upgrade the TAT payload with greater thrust and longer burn-time; main engine thrust, 348,000 lbs.; solid strap-ons upgraded to 70,450-lb. thrust each.

TITAN II (GLV) (NASA)
Aerospace Corp., systems engineering & technical direction; Martin, prime. DESCRIPTION: Manned space booster; Essentially TITAN II with addition of redundant electrical power and flight control systems, malfunction detection system and radio command guidance. STATUS: Development; GT-2 (unmanned version) launched Jan. 19; GT-3 successful on March 23; GT-4, June 3, and GT-5, Aug. 21, also successful, as were GT-7 Dec. 4 and GT-6 Dec. 15.

TITAN III (Air Force Program 624A)
Aerospace Corp., systems engineering & technical direction; Martin, systems integration; United Technology, large solid boosters; Martin, TITAN II portion; Aerojet-General, liquid engines (Transtage); Martin, standardized upper stage; AC Spark Plug, guidance. DESCRIPTION: Quick-reaction vehicle for military space missions; will be used to boost MOL/GEMINI-X; Zero stage, two 120-in. solid motors; first and second stages, TITAN II (storable propellants); third-stage is liquid Transtage; modified TITAN II guidance; payload, 25,000 lbs. in 100-n.mi. orbit, 2,100 lbs. to 22,300-mi. orbit; 5,000 lbs. to escape; STATUS: Development; first flight Sept. 1, 1964 (T-IIIA) achieved primary and secondary objectives, but failed to achieve orbit; second flight (T-IIIA) successful Dec. 10, 1964; first full TITAN III-C flight successful June 18, 1965; second flight Oct. 15, successful launch followed by partial Transtage failure; third launch Dec. 21 also had partial control failure; eight remaining III-C R&D flights; next three for IDSCP; development stretchout moves operational date to June, 1967; a non-man-rated version—TITAN III-B—being studied as more cost-effective booster for satellite launches; uses first two TITAN III-A stages and an AGENA upper stage; first launch, mid-1966; 24 vehicles planned as initial buy; 7-segment version of III-C expected to boost MOL.

missiles

ADVANCED SURFACE MISSILE SYSTEM (Navy)
Raytheon, Boeing, Sperry Rand, General Electric, Westinghouse, RCA & Hughes, pre-program definition contracts. DESCRIPTION: Fleet air-defense weapon for the 1970 time period; to have capability against aircraft and certain types of air-to-surface missiles; will replace the 3-T systems currently in the fleet. STATUS: Will remain in early development status for one year while Army's SAM-D project is monitored for possible ASMS commonality; Navy requests $2 million for ASMS in FY '67.

ALFA (RUR-4) (Navy)
Navy, prime; Avco, frame; Naval Propellant Plant, propulsion. DESCRIPTION: ASW, surface-to-underwater; weight, 500 lbs.; solid propulsion; H.E. depth charge; range, 1,000 yds.; guidance, free-flight. STATUS: Operational; deployed on destroyers and cruisers; being replaced by ASROC.

ANTI-SATELLITE WEAPON (Army/Air Force)
Boeing, AF program; Hughes, terminal guidance (IR), AF program; Douglas, THOR and ZEUS vehicles and support services; A. D. Little, operations analysis. DESCRIPTION: Consists of both NIKE-ZEUS and THOR-AGENA w/terminal stage programs; intercepts have been accomplished at "hundreds of miles," according to Secretary McNamara. STATUS: Operational, according to DOD.

ARM I (Navy)
No contractor announced. DESCRIPTION: Longer-range, smaller anti-radiation missile than SHRIKE for armament of F-111B and A-7A aircraft. STATUS: Development funds requested in FY '67; also $4 million asked for ARM technology beyond ARM-I.

ASROC (RUR-5A) (Navy)
Honeywell, prime; Sangamo Electric, sonar; GE, torpedo; Librascope-General Precision, fire control. DESCRIPTION: ASW, surface-to-underwater; weight, 1,000 lbs.; solid propulsion; warhead, nuclear or conventional torpedo; range between 1,800 yds. and 8 mi.; guidance, unguided. STATUS: Operational on DE, DD, DLG, & heavy cruisers; one "live" weapon fired in 1962 Pacific nuclear tests; extended-range version in pre-program definition phase; version adaptable to TERRIER launchers being developed; FY 1966 procurement to complete Navy's stock needs; new funds requested for follow-on ASW missile compatible with ASROC launcher and fire control.

BOMARC B (AIM-10B) (Air Force)
Boeing, prime; General Precision Aerospace/Westinghouse/IBM, guidance; Thiokol/Marquardt, propulsion. DESCRIPTION: Surface-to-air; weight, 16,000 lbs.; solid booster/ramjet propulsion; warhead, nuclear; range, more than 400 n.mi.; guidance, command via SAGE; speed, Mach 2.7. STATUS: Three bases operational; production completed; the 188 B models will be distributed among the eight bases after the A model is phased out; all A missiles at five bases operational in northeastern U.S. phased out by the end of FY 1965.

BULLPUP (AGM-12 B & C) (Navy-Air Force)
Martin, systems cognizance; Maxson Electronics Co., production; Thiokol, liquid and solid propulsion; Naval Propellant Plant, solid propulsion (motor loading). DESCRIPTION: Air-to-surface, range, 3-6 mi.; guidance (visual reference), radio-link command. BULLPUP A: Solid propulsion; warhead, 250-lb. H.E. BULLPUP B&C: pre-packaged liquid motor; warhead, 750-lb. H.E. STATUS: BULLPUP A deployed with Atlantic and Pacific Fleets; operational with U.S. Air Force & NATO units; training version (ATM-12) being procured by both services; being produced in Europe for NATO; procurement of larger warhead version for both Navy & AF renewed with FY '66 supplemental.

CHAPARRAL (Army)
A surface-to-air adaptation of the Navy's air-to-air SIDEWINDER; mounted on vehicles, in a 4- or 6-missile configuration. Philco's Aeronutronic Div. is prime; CHAPARRAL will be on interim, fair-weather-only solution to forward-area air defense; has been successfully fired; production increased substantially; more battalions formed. (See: SIDEWINDER.)

CONDOR (AGM-53) (Navy)
In-house project, Naval Ordnance Test Station, North American Aviation, Columbus Div. and Northrop Norair Div. completed PDP studies. DESCRIPTION: Air-to-surface TV-guided, stand-off weapon; configuration classified; range, 40 mi. STATUS: Development funds requested in FY '67; intended for use with Navy version of F-111 and on A-6 aircraft.

DAVY CROCKETT (M-38B) (Army)
In-house project directed by Army Weapons Command at Rock Island, Ill. DESCRIPTION: Surface-to-surface; solid propulsion, bazooka-launched; warhead, sub-kiloton nuclear; guidance, free flight; two launchers—vehicle-mounted or carried by two men. STATUS: Operational in Europe.

ENTAC (MGM-32A) (Army)
Nord Aviation, prime. DESCRIPTION: Anti-tank; weight, 37 lbs. with launcher; solid propulsion; warhead, shaped-charge H.E.; range, 6,600 ft.; guidance, wire-guided; man-portable. STATUS: Operational; procurement complete; will be replaced by TOW.

FALCON (AIM-4A, C, E, F/26A/47A) (Air Force)
Hughes, prime; Hughes, guidance; Thiokol, AIM-4/26 propulsion; Lockheed Propulsion, AIM-47 propulsion. DESCRIPTION: Air-to-air; weight (AIM-4/47), more than 100 lbs. — (AIM-26), more than 200 lbs.; range 5 n.mi.; supersonic; solid propulsion; warhead, H.E. (except for AIM-26B, which carries nuclear warhead); AIM-4A, and 4E, active radar homing guidance; AIM-4C, and 4F, IR homing; AIM-26 model has nuclear warhead and hybrid IR radar homing. STATUS: Operational buy-out of 4E, 4F and 26 in FY '62; AIM-47 is the armament for YF-12A (A-11); several versions operational on F-101, F-102 and F-106.

GENIE (AIR-2A) (Air Force)
Douglas, prime; Aerojet-General, propulsion. DESCRIPTION: Air-to-air; weight 800 lbs.; unguided; solid propulsion; warhead, nuclear; range, 6 n.mi.; guidance, free flight; supersonic; proximity fuzing. STATUS: Procurement complete; operational on F-101B and F-106; improved version cancelled; launcher being developed by McDonnell for adaptation to F-4 aircraft.

HAWK (MIM-23A) (Army)
Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion. DESCRIPTION: Surface-to-air; weight, 1,275 lbs., solid propulsion; warhead, H.E.; range, 22 mi.; guidance, semi-active radar homing; 100-45,000-ft. ceiling; provides defense against medium and low-flying aircraft and cruise-type missiles. STATUS: Operational; deployed in Europe, Panama, Okinawa, South Vietnam, U.S. (13 battalions); bought by Sweden and Israel; R&D being conducted to adapt selected HAWK units to an anti-tactical ballistic missile; NATO producing; Japan also buying; FY '66 procurement increased for Vietnam replacement; new improvement program requested in FY '67; self-propelled version also under development; large-scale buy by Saudi Arabia; sales to other Arab nations include Iran, Iraq and Lebanon.

HIBEX (ARPA/Army)
Boeing, prime; Hercules and Aerojet, propulsion. DESCRIPTION: Experimental program in high-energy propellants; cone-shaped missile; performance classified; solid propulsion. STATUS: Development; accelerations of 800 to 1,000 g's goal; static test of motor successful November, 1964; flight test program of 10 vehicles being conducted at WSMR; third successful flight Oct. 28 was first from underground cell at WSMR; Up-Stage program started to add second stage and increase range; evaluation now underway of recent flights in conjunction with HAPDAR phased-array radar.

HONEST JOHN (MGR-1A) (Army)
Douglas/Emerson Electric, prime; Hercules, propulsion. DESCRIPTION: Surface-to-surface; weight, 5,900 lbs.; single-stage solid propulsion; warhead, nuclear; range, 12 mi. (M-31), 20 mi. (M-50); unguided. STATUS: Operational; M-50 being deployed in Europe; to be replaced by LANCE; procurement complete.

HORNET (ZAGM-64A) (Air Force)
(Formerly known as ATGAR). Concept based on North American Aviation Columbus Div. unsolicited proposal, funded by AF. DESCRIPTION: Air-launched, anti-tank weapon; electro-optical guidance. STATUS: pre-development, AF procuring missiles for test at Eglin AFB; Army interested in potential use on helicopters; HORNET also used as demonstration vehicle for new NAA TV-guidance system for MAVERICK (AGM-65A), a new tactical air-to-surface missile for which the AF is expected to ask DOD approval.

HOUND DOG (AGM-28B) (Air Force)
North American, prime; Autonetics, guidance; Pratt & Whitney, propulsion. DESCRIPTION: Air-breathing air-to-surface standoff missile; weight, 9,600 lbs.; turbojet propulsion; warhead, nuclear; range, about 600 n.mi.; guidance, all-inertial; ceiling in excess of 50,000 ft.; Mach 2+. STATUS: Operational; to be launched from B-52G intercontinental bombers; procurement complete; new terminal guidance being developed.

LANCE (XMGM-52A) (Army)
LTV Aerospace, prime; Systron-Donner, guidance. DESCRIPTION: Highly mobile general-purpose missile; very light weight; pre-packaged storable liquid propellant; warhead, nuclear and H.E.; range, 70 km; guidance, Automet inertial, one missile per launcher. STATUS: Initial procurement in FY '67, with large scale production likely; eventually will replace HONEST JOHN, LACROSSE and perhaps LITTLE JOHN; division support weapon; may also replace some tube artillery; to use multi-system test equipment; Navy requests $2 million for start on new "Landing Force Support Weapon" using sea-based LANCE.

LITTLE JOHN (MGR-3A) (Army)
Emerson Electric, prime; Hercules Powder, propulsion. DESCRIPTION: Surface-to-surface; weight, 800 lbs.; solid propulsion; warhead, nuclear; range, 10 mi.; unguided, supplements medium and heavy artillery in airborne divisions and air-transportable commands. STATUS: Two battalions activated in 1961; each equipped with four launchers; air- and helicopter-transportable; may be replaced by LANCE.

MACE (MGM-13A, CGM-13B) (Air Force)
Martin, prime; Goodyear/AC Spark Plug, guidance, Thiokol/Allison, propulsion. DESCRIPTION: Air-breathing surface-to-surface; weight, 18,000 lbs.; turbojet and solid propulsion; warhead, nuclear and H.E.; range, over 650 n.mi. (Model A), over 1,200 n.mi. (Model B); guidance, map-matching (A), inertial (B). STATUS: Five MACE-A and one MACE-B squadrons (in hard sites) deployed in Europe; two MACE-B squadrons on Okinawa in hard sites.

MAW (Army)
McDonnell Aircraft Corp. version of Medium Anti-Tank/Assault Weapon selected for development. DESCRIPTION: Surface-to-surface; solid propellant, range, 500-1,500 yds.; shoulder-fired; wire-guided; weighs about 30 lbs. STATUS: Full-scale development will begin in FY '67; studies will continue of possible use of some techniques from Army Missile Command version.

MINUTEMAN (LGM-30) (Air Force)

TRW Systems Group, systems engineering and technical direction; Boeing, major contractor; Autonetics, guidance, Thiokol, first-stage propulsion; Aerojet, second-stage propulsion; Hercules, third-stage propulsion; Avco, re-entry vehicle; GE, MARK 12 re-entry vehicle, MINUTEMAN II. DESCRIPTION: 2nd-generation ICBM; weight, over 65,000 lbs.; solid propulsion; warhead, nuclear; 3 stages; range, 7,000 mi; guidance, all-inertial, target selected in seconds; 32-sec. reaction time. STATUS: First 10 MINUTEMAN II's operational since October; at least 200 operational by end of FY '67 to complete 1,000-missile force; 800 MINUTEMAN I's now operational; advanced version can be fired by airborne command posts; deployed in hardened and dispersed silos; all MINUTEMAN I missiles to be replaced by MINUTEMAN II in phased replacement program costing $1 billion; MMII has greater accuracy (nearly 8 times more) and range-payload than I version; MINUTEMAN III, with advanced re-entry vehicle probably maneuverable and carrying multiple warheads, will be procured initially in FY '67.

NIKE-HERCULES (MIM-14B) (Army)

Western Electric, prime; Western Electric, guidance; Hercules and Thiokol, propulsion; Douglas, airframe. DESCRIPTION: Surface-to-air, anti-aircraft, tactical; weight, 10,000 lbs.; solid propulsion; warhead, nuclear or H.E.; range, 75 mi.; guidance, command; Mach 3+; ceiling in excess of 150,000 ft. STATUS: Over 80 batteries deployed in U. S. being turned over to National Guard; over 10 N-H batteries deployed overseas; Japan plans additional procurement; being equipped with HIPAR, a high-power acquisition radar, and anti-tactical-ballistic-missile capabilities. Re-location of some HERCULES batteries under consideration by JCS.

NIKE-X/Zeus (XLIM-49A) (Army)

Western Electric, prime; Bell Telephone, guidance; Thiokol/Lockheed, propulsion; Douglas, airframe. DESCRIPTION: Anti-missile missile, 3-stage; weight, 22,800 lbs.; solid propulsion; warhead, nuclear; range, 200-mi.; guidance, command; length, 48 ft.; diameter, 36 in.; fin span, 10 ft. STATUS: Missile is now part of NIKE-X missile "mix"; development, except as part of X, has ended; no intercept "failure" in more than a year of tests; advanced version of ZEUS (DM15X2) now under development reflects important breakthrough in long-range (400-mi.) ICBM interception.

NIKE-X (Army)

Western Electric, prime; Bell Telephone, guidance; Thiokol, ZEUS propulsion; Douglas, ZEUS airframe; Martin Marietta, SPRINT missile prime; Hercules and Lockheed, SPRINT propulsion. DESCRIPTION: Successor to ZEUS as an anti-ICBM system; uses a mix of ZEUS/SPRINT missiles and multi-function array radar (MAR). STATUS: Engineering development; funded at $447 million in FY '67 on accelerated development schedule, but deployment still deferred; full system tests to be conducted this year from Kwajalein Is. with new modular radars; deployment cost: $8-20 billion depending on version; more optimism seen for light-attack version.

PERSHING (MGM-31A) (Army)

Martin, prime; Bendix, guidance; Sperry Farragut, fuzing and aiming; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; two-stage solid propulsion; warhead, nuclear; range, approx. 400 n.mi.; guidance, inertial; transported on FMC M474 tracked vehicles; replaced REDSTONE. STATUS: Flight test program completed; troop firings from Ft. Wingate, N.M., to White Sands being conducted; number of missile-loaded launchers per unit to be increased; West Germany organizing two battalions; first U. S. PERSHING battalion deployed to Germany in April, 1964; new modification program to improve reliability and rate of fire.

PHOENIX (AIM-54) (Navy)

Hughes Aircraft Co., prime; Rocketdyne, propulsion. DESCRIPTION: Air-to-air missile for use with the F-111B fighter aircraft; each aircraft will be able to carry six missiles; missile control system designated AN/AWG-9; and missile/bomb launcher is MAU-48A. STATUS: Development; first flight test planned in March, 1966 but program has slipped substantially because of continuing development problems and Navy uncertainty over F-111B.

POLARIS (UGM-27 A, B, C) (Navy)

Lockheed, prime; GE/MIT/Hughes/Honeywell/Roytheon, guidance and fire control; Aerojet-General/Hercules, propulsion; Lockheed, re-entry vehicle; Nortronics, checkout; Autonetics/Sperry, SINS; Westinghouse, launching equipment; Vitro, systems engineering coordination and training; Systron-Donner, ignition programming. DESCRIPTION: Underwater- and surface-to-surface; weight, 30,000 lbs.; solid propulsion; warhead, nuclear; range, 1,200 n.mi. (A-1), 1,500 n.mi. (A-2), 2,500 n.mi. (A-3); guidance, all-inertial. STATUS: 29 subs operational each with 16 A-2 or A-3 missiles; all A-1's now retired; total of 41 POLARIS subs authorized; to be operational by FY '68, includes 13 with A-2, 28 with A-3; British to buy A-3 missiles from U.S. POSEIDON, follow-on FBM, now in full-scale development; same contractors as POLARIS except for propulsion—Hercules/Thiokol first stage; Hercules second stage; same range as A-3 with double payload and accuracy; 50-month development effort; may go aboard 19 subs; PenAids and warhead can be field-changed; FY '67 funds are $300 million; total program costs are $1.3 billion.

QUAIL (ADM-20C) (Air Force)

McDonnell, prime; McDonnell, electronics, guidance; GE, propulsion; TRW, Inc., ECM equipment. DESCRIPTION: ECM-carrying decoy, which simulates B-52 bomber to enemy radar; turbojet powered; range, 250 mi.; guidance, gyroscopic autopilot. STATUS: Deployed at SAC bases; carried by B-52; procurement completed FY '61; advanced version with 400-mi. range has been flight tested.

REDEYE (XFIM-43B) (Army)

GD/Pomona, prime; Atlantic Research, propulsion; MPB, Inc., seeker optics. DESCRIPTION: Surface-to-air; weight, 28 lbs.; solid propulsion, warhead, conventional; guidance, IR homing; length 48 in.; diameter, 2.75 in. STATUS: Production; tests against helicopters and jets at NOTS successful.

REGULUS I (RGM-6) (Navy)

LTV Aerospace Corp., prime; Sperry, guidance; Allison, propulsion. DESCRIPTION: Surface-to-surface; weight, 14,000 lbs.; turbojet and solid propulsion; warhead, nuclear; range, 500 n.mi.; guidance, inertial; speed, about 600 mph; ceiling, approx. 40,000 ft. STATUS: Five REGULUS subs with 17 missiles are operational now; 3 subs (8 missiles) phased out in FY '65.

SAM-D (Formerly AADS-70) (Army)

Hughes/Douglas/FMC, RCA/Beech, competitive component development contracts. DESCRIPTION: Field army aircraft/missile defense system, mobile. STATUS: DOD approved Army go-ahead for CDP; RFP's for CDP expected this spring; full-scale development on accelerated basis approved for FY '67; missile will replace both HAWK and NIKE-HERCULES; production could cost more than $2 billion.

SERGEANT (MGM-29A) (Army)

Sperry Utah, prime; Sperry, guidance; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; solid propulsion; warhead, nuclear; range, over 75 n.mi.; guidance, inertial; uses drag brakes. STATUS: Operational procurement complete; deployed in Europe.

SHILLELAGH (MGM-51A) (Army)

Philco Aeronutronic, prime, Picotinny Arsenal/Amoco Chemicals Corp., propulsion; Aeronutronic, guidance. DESCRIPTION: Surface-to-surface; lightweight; solid propulsion; warhead, nuclear or H.E.; guidance, command; vehicle-mounted for use against field fortifications, armor and for close-in support of troops. STATUS: Large-scale production; second-source procurement expected; to use multi-system test equipment; to be installed on Gen. Sheridan assault vehicle; also being considered for use on helicopters; Philco has contract to adapt missile to Army's M-60 tank.

SHRIKE (AGM-45A) (Navy)

Naval Ordnance Test Station-China Lake, prime; Texas Instruments, guidance and control; North American Rocketdyne (McGregor), propulsion. DESCRIPTION: Air-to-surface, anti-radar; solid propulsion; guidance, passive radar homing. STATUS: Operational with Navy and Air Force but many problems; advanced version under accelerated development and will probably be bought by AF and Navy.

SIDEWINDER 1-C (AIM-9C&D) (Navy, Air Force)

Naval Ordnance Test Station, technical direction; Philco, IR guidance, Motorola, radar guidance; Naval Ammunition Depot, McAllister, motor loading; Rocketdyne (McGregor), propellant. DESCRIPTION: Air-to-air; weight, about 185 lbs.; solid propulsion; warhead, H.E.; range, more than 2 mi. STATUS: 1-A and 1-C deployed with Navy and Air Force; NATO-built version in production. (See CHAPARRAL.)

SPARROW III-6B (AIM-7E) (Navy)

Raytheon, prime; Raytheon, airframe, control, guidance; Aerojet-General/North American Rocketdyne (McGregor), propulsion; McDonnell/Benrus Watch Co., launcher. DESCRIPTION: Air-to-air; weight, 350 lbs.; solid propulsion; warhead, conventional; range, 5-8 mi.; guidance, semi-active CW homing; Mach 2.5-3; ceiling, over 50,000 ft. STATUS: Operational with Navy and AF aircraft; SPARROW III-6B prime armament for Phantom II (F-4B) and other high-performance interceptors; Italians buying NATO version for use on new F-104S; sales to West Germans and other NATO F-104 consortium memmers possible; advanced version under development for Navy; Navy also to develop SPARROW as point defense missile system for shipboard air defense.

SPRINT (Army)

Martin-Orlando, prime; Hercules Powder/Lockheed Propulsion Co., propulsion; Bell Telephone Laboratories, guidance. DESCRIPTION: High-acceleration cone-shaped maneuverable missile for low-altitude interception of ballistic missiles; 4.5-ft. base diameter, 27 ft. long; two-stage; nuclear; missile will be popped out of silo before motor is ignited; to be part of the missile mix in a NIKE-X battery. STATUS: Development; first flight in March, 1965, tested vehicle aerodynamically; successfully tested from silo Nov. 17 at WSMR; extensive guidance tests underway; tests to move to Kwajalein in 12-18 months for use with NIKE-ZEUS and full radar system.

SRAM (Air Force)

Boeing and Martin Marietta won CDP awards of $2.75 million each. DESCRIPTION: Air-to-surface defense-suppression stand-off missile for use with the B-52, B-58, F-111 or the Advanced Manned Strategic Aircraft. STATUS: Accelerated development in FY '67; $40 million requested.

STANDARDIZED MISSILE (Navy)

No contractors. DESCRIPTION: Fleet air-defense missile to replace TARTAR-TERRIER and give Navy a single missile to perform both missions; longer-range targets (30+ miles) would be engaged by adding a booster to the shorter-range (10+ miles) weapon; similar to the homing TERRIER now being procured. STATUS: Development; production funds requested; intended to work with new TARTAR-D digital fire control.

SUBROC (UUM-44A) (Navy)

Naval Ordnance Laboratory, technical direction; Goodyear, prime; General Precision Aerospace, guidance; Thiokol, propulsion; General Precision Librascope, fire control. DESCRIPTION: Underwater-air-underwater anti-submarine missile depth bomb; solid propulsion; warhead, nuclear, weight, 4,000 lbs.; length, 21 ft.; diameter, 21 in.; range, 25-30 mi.; guidance, inertial. STATUS: Operational evaluation completed, now being deployed on Permit-class submarines.

SS-10 (MGM-21A) (Army)

Nord Aviation, prime. DESCRIPTION: Surface-to-surface, primarily anti-tank; weight, 33 lbs.; solid propulsion; warhead, conventional; range, 1,600 yards; wire-guided. STATUS: Operational with U.S., French and other NATO and Western units; battle-tested in North Africa; U.S. replacing with ENTAC.

SS-11 (AGM-22B) (Army)

Nord Aviation, prime. DESCRIPTION: Surface-to-surface anti-tank, also helicopter-to-surface; weight, 63 lbs.; solid propulsion; wire-guided; warhead, conventional; range, 3,800 yds. STATUS: Operational, used with airborne units and Army helicopters; AS-12 being considered by Navy for ASW aircraft.

TACTICAL PROBE (Navy)

Bendix, prime: DESCRIPTION: Surface-to-air; multiple, interchangeable payloads for each mission; booster, TERRIER or TALOS from shipboard installations; high-impulse second stage; range, 50-300 mi.; parachute descent. STATUS: Program definition; a new study has been authorized, and is under way, to evolve a cheaper program.

TALOS (RIM-8E) (Navy)

Bendix, prime; Vitro, systems engineering; McDonnell/Hercules Allegany Ballistics Lab., propulsion; Sperry, guidance; GE, launching gear. DESCRIPTION: Ship-to-air; weight, 7,000 lbs.; solid and ramjet propulsion; warhead, nuclear; range, 65 n.mi.; guidance, radar beam riding/semi-active homing; Mach 2.5. STATUS: Operational aboard cruisers Galveston, Little Rock & Oklahoma City and three Albany-class DEG's; Long Beach, nuclear-powered cruiser, has advanced TALOS; "3-T" get-well program intended to improve reliability; procurement continuing.

TARTAR (RIM-24B) (Navy)

Vitro, systems coordination engineering; Applied Physics Lab, design and development; GD/Pomona, Aerojet-General, propulsion; Sperry Farragut, fuze (target detection device). DESCRIPTION: Ship-to-air; weight, 1,500 lbs.; solid dual-thrust motor; warhead, conventional; range, 10 n.mi.; guidance, semi-active homing; Mach 2. STATUS: Operational; installed aboard 23 guided missile destroyers and three cruisers equipped with TALOS; get-well program progressing; no additional missile buy.

TERRIER (RIM-2E) (Navy)

Vitro, systems engineering; GD/Pomona, prime; GD/Pomona, guidance section; Sperry, radar; Hercules Allegany Ballistics Laboratory, propulsion; Northern Ordnance, launching gear. DESCRIPTION: Ship-to-air; weight, 3,000 lbs.; 27 ft. long; solid propulsion; warhead, conventional; range 10 n.mi.; guidance, radar beam-riding or homing; Mach 2.5. STATUS: Operational aboard two attack carriers, 6 cruisers, and 12 missile frigates; get-well program progressing; being used in test firings against surplus REDSTONE missiles; no additional missile buy.

TITAN II (LGM-25C) (Air Force)

Martin, prime; TRW Systems Group, systems engineering and technical direction; AC Spark Plug, guidance; Aerojet-General, propulsion; GE, re-entry vehicle. DESCRIPTION: ICBM; weight, 330,000 lbs.; N_2O_4 and Aerozine-50 storable fuels; warhead, nuclear; range, over 5,000 mi.; guidance, inertial; 115 ft. long; 2 stages; greatest payload and range of any U.S. ICBM, basic core vehicle for TITAN III booster. STATUS: All 54 missiles operational in 18-missile squadrons at Davis-Monthan AFB, McConnell AFB, and Little Rock AFB.

TMRBM (Air Force)

No contractors announced, but probably would be same team producing the second and third stages of MINUTEMAN II. DESCRIPTION: A transportable mid-range missile to fill the gap left by cancellation of MMRBM; it would use the top two stages of MM II and the MM II guidance system; would weigh more and be less mobile than MMRBM, but could be developed for approximately one-third the cost; reaction time also less than MMRBM's; employment concept much the same as that of the Russian-deployed missiles in Cuba in 1962. STATUS: Study by the Air Force at DDR&E direction; not likely to be developed due to a lack of mission.

TOW (XMGM-71A) (Army)

Hughes, prime. DESCRIPTION: Anti-tank; weight, 160 lbs.; solid propulsion; warhead, H.E.; wire-guided; optically tracked; tube-launched. STATUS: Development; follow-on to ENTAC; successful firings have been conducted; helicopter use planned.

WALLEYE (Navy)

Martin Co., prime; NOTS development; TV-guided glide bomb with good stand-off range; large buy expected for AF and Navy; smaller version, called SNIPE, under NOTS development for Army helicopters.

ZUNI (Navy)

Naval Ordnance Test Station, prime; Hunter-Douglas, propulsion. DESCRIPTION: air-to-surface; weight, 107 lbs.; solid propulsion; warhead, conventional; range, 5. n.mi.; unguided. STATUS: Operational; designed for use on jet fighter and attack aircraft; big increase in orders because of Vietnam war.

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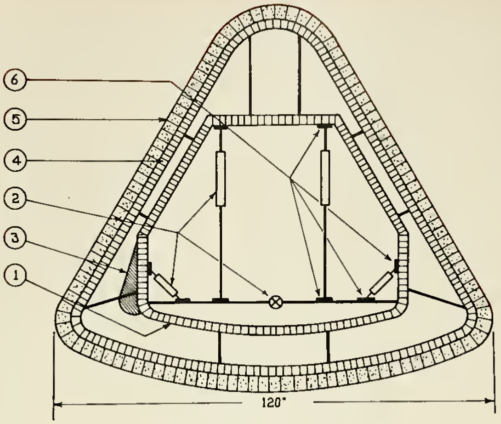

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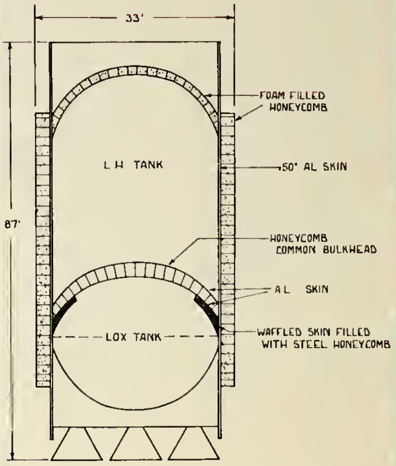
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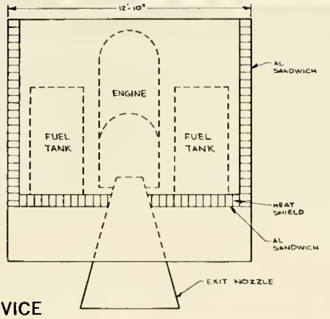
S-II STAGE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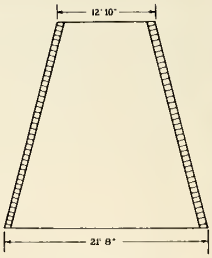

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Technical Countdown

ELECTRONICS

Laser Beams Automatically Analyzed

To protect the eyes of operators of high-power lasers, a Holloman AFB engineer has developed an automatic detector and analyzer. The instrument can be used by researchers to determine in real time the characteristics of a laser beam, including transverse electromagnetic modes. The device permits both study and optimal tuning of any CW laser without exposing the investigator to radiation. It consists essentially of an X-Y plotter and oscilloscope, photodiode sensor, and an oscillating mirror to move the light beam in a "scan" mode.

Laser Safety Interest Widespread

Following an initial distribution of 500 booklets on Laser Safety Procedures prepared by the Martin Co.'s Orlando Div. last year, nearly 2,000 additional requests for copies have been received by the Florida facility. The booklet is now in its third printing.

MATERIALS

New Optical Materials Developed

Mirrors for the solar reflecting telescopes in the McMath-Hulbert Observatory of the University of Michigan are being made by Owens-Illinois, Inc., from Cer-Vit—a low-expansion material. The thermal expansions of Cer-Vit materials can be controlled to within $\pm 10^{-7}$ in. per degree C and should help solve the stability problem associated with large mirrors and ambient temperatures. The primary mirrors being processed by Owens-Illinois are 41 in. in diameter and the low expansion permits continuous grinding and polishing operations. The Cer-Vit materials are melted and formed as glasses and then converted to partially crystalline bodies by controlled processing. A wide choice of compositions, crystallizing procedures and other treatments is available.

Unique Sterilization Method Developed

Propellant research by NASA has yielded a method of sterilizing or largely decontaminating a thermosetting plastic in its liquid form. NASA scientists suggest that the plastic could be used to provide a self-sterilizing coat for any surgical instrument or other object dipped into it. The plastic would then cure, and be easily ripped off before the instrument is needed.

INFORMATION SYSTEMS

Tech Communications Committee Founded

A committee on scientific and technical communication has been established in a joint venture by the National Academy of Sciences and the National Academy of Engineering. The action was taken in response to a request by the National Science Foundation. The new committee will serve as a focal point for the participation of scientists, engineers and their societies in the planning of a national network of information systems in science and technology.

Dr. Robert W. Cairns, research director for Hercules Powder Co., will chair the 14-member committee. Members are leaders in academic and industrial research and technology.

SPACE MEDICINE

Biosatellite Advance Reported

Jet Propulsion Laboratory scientists have developed a method of in-orbit wet chemical analysis of urinary biochemical constituents for the *Biosatellite* primate flights. The development was made necessary by the inability to provide a urine collection system. The fluorometric system will automatically analyze the primate urine for creatine, creatinine, urea and calcium four times each day. NASA hopes to obtain indications of general metabolism, including muscle, bone, kidney, heart, and perhaps stress responses.

New Implantable Bioinstrumentation Developed

Franklin Institute is miniaturizing a multi-channel implantable device which will be used in the next year to measure at least two sensing parameters in unrestrained, small, laboratory mammals. Performance studies are under way to determine operational lifetime, measurement accuracy and precision, and effects of changes of ambient temperatures. NASA's Office of Space Sciences and Applications is supporting the project.

Device Detects Chromosome Changes

An automatic electronic device utilizing computer analysis for scanning, recording, counting and assorting chromosomes is attracting interest at NASA for study of chromosomal changes in animals and men after spaceflight, and for detection of extraterrestrial life. NASA's Office of Space Sciences says that a model of the microscope part of the device is now undergoing reliability tests.

Lunar Study Under Way at Honeywell

Two NASA officials will emerge this week from a cylindrical chamber at Honeywell, Inc., in which they are acting as subjects for a human factors study on lunar vehicles. Marshall Space Flight Center's Michael J. Vaccaro and Haydon Grubbs are participating in the experiment, aimed at determining: the functional relationships between physiological responses and behavior and task performance time; optimum design of lunar-roving vehicles for crew mobility and cabin space utilization; and means to increase performance proficiency. Unpressurized and pressurized spacesuits have been worn.

Stress Hormone Detected

A new hormone which resembles vasopressin but appears to arise from another area in the brain looks promising in detecting stress responses of human beings. Dr. Evelyn Anderson of NASA's Ames Research Center has developed a method of detecting the stress hormone with an eye to determinations of astronaut welfare. The hormone appears to be secreted in response to such stresses as blood loss or violence, and passes to the pituitary gland, where it activates the release of ACTH. Both ACTH and the hormone then pass into the general circulation system, where the latter can be measured in the blood.

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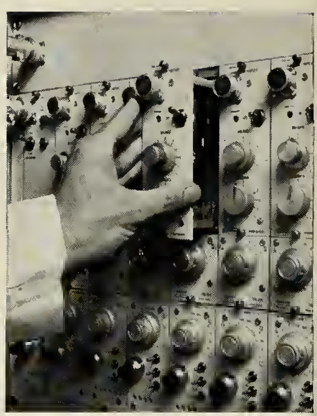

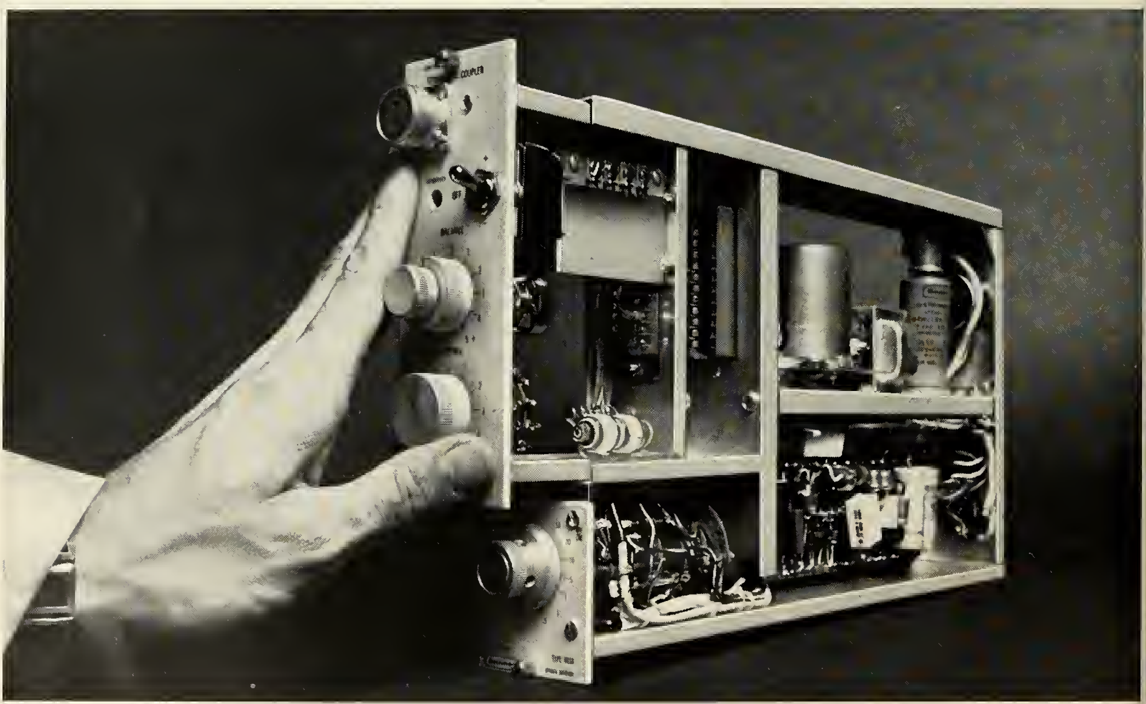

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Circle No. 7 on Subscriber Service Card

New TVC Development Uses Free Air

Air scoops divert ambient air into rocket motor throat to do away with need for thrust-vector-control liquids

by Robert Lindsey

SUNNYVALE, CALIF.—A thrust vector control system for steering large rockets which uses only atmospheric pressure to deflect the rocket's exhaust stream has been developed by United Technology Center.

UTC says its studies indicate that the system offers impressive weight savings, payload increases and cost advantages for rockets ranging from large solid motors down to small tactical weapons.

Based on an amazingly simple idea, the so-called "free air" TVC system generates steering side force solely from ambient air admitted into the nozzle.

Used from sea level up through the atmosphere, the free air system is as effective as conventional liquid-injection TVC systems employing fluids such as freon or nitrogen tetroxide, according to Dr. Henry T. Hsia, the UTC staff scientist credited with its invention.

Lighter weight—Yet, Hsia said, the new system eliminates much of the weight and complexity of standard fluid injection TVC systems and offers a bonus: Some of the injected air reacts chemically with the exhaust gases, adding to the total impulse of the propellant. In a large solid motor, for example, the air augmentation boosts the effective specific impulse of the motor by about 2%, Hsia said.

While most initial research on the free-air TVC system has been directed toward large solid motors, Hsia said it could be used with all types and sizes of rockets.

He said it appears particularly promising for large amounts of maneuvering, such as air-to-air, surface-to-air or low-altitude missiles require, or for a maneuvering re-entry vehicle below 120,000 ft.

Because air is the steering system's only expendable fuel, the system imposes virtually no limitation on a vehicle's maneuverability.

The principal components of the system are the injection ports—there are four per quadrant—a scoop-like collar around the nozzle, and the nozzle itself. Key to the design is the location of the ports in the nozzle, a secret which UTC maintains for proprietary reasons.

Hsia said atmospheric pressure is adequate to steer missiles or launch vehicles from sea level into space.

At lift-off, sea-level pressure, admitted into the lower-pressure area in the nozzle, provides more than enough force to deflect the exhaust stream of a 1-million-lb.-thrust-class solid motor at least five degrees, Hsia said.

At altitude, the cup-like scoop around the nozzle collects air and rams it through the TVC ports.

Even pressure—As the rocket accelerates and the atmosphere becomes thinner, the pressure curve of the injected air remains relatively constant. The decreasing atmospheric pressure is compensated for by an increase in speed.

Hsia calculates that using the new TVC system with a large solid motor like the 120-in., 1.2-million-lb.-thrust motor UTC developed for the *Titan III-C* would reduce weight by as much as 30% and increase payload by 3½%.

He estimates that an air injection system for the five-segment 120-in. motor would weigh 4,600 lbs., compared with the 20,000-lb. nitrogen tetroxide system now used in the *Titan III-C*.

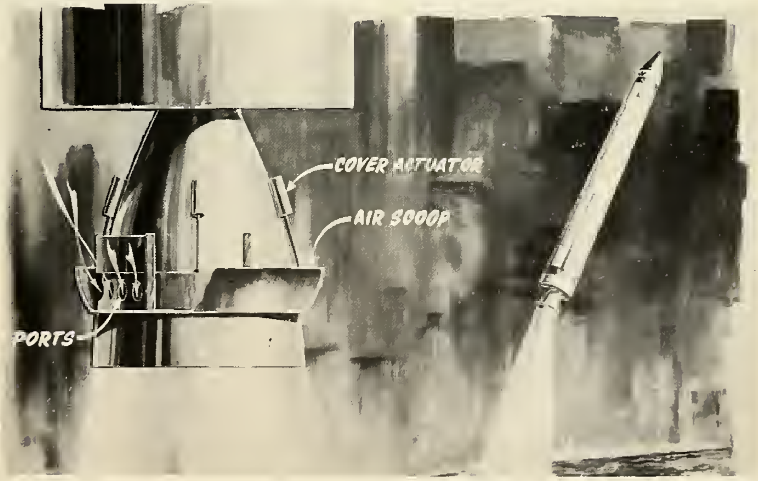
In most parameters, Hsia said, the new technique appears to be equal to a hot gas valve system. However, he said it has the added advantage of offering an unlimited amount of TVC injectant fluid to handle all mission variables. Additionally, it poses none of the problems with heating and materials that a hot-gas system would entail.

For a *Titan III-C* class solid motor, Hsia said, the injection ports would be 90-degree circumferential slots, eight inches wide.

Use of the free-air TVC technique would require a considerably larger nozzle than is used in convential designs.

For a 1-million-lb.-thrust-class rocket, like the *Titan III-C* motor, which has a nominal chamber pressure of 550 psi, the nozzle in the new system would have a total expansion ratio of 13, compared with a present eight.

UTC's new free-air TVC system scoops ambient air into rocket motor to deliver as much as five degrees of thrust deflection in 1-million-lb.-class motors.



Hsia said addition of the air cowling on the nozzle would increase drag on a rocket, but this is more than overcome by the increase in the total impulse resulting from the air augmentation.

Expansion ratio—Still another bonus of the free air system, Hsia added, is that it uses the air-inlet openings to moderate the nozzle's effective expansion ratio to a near-optimum curve as the rocket goes from sea level through the atmosphere.

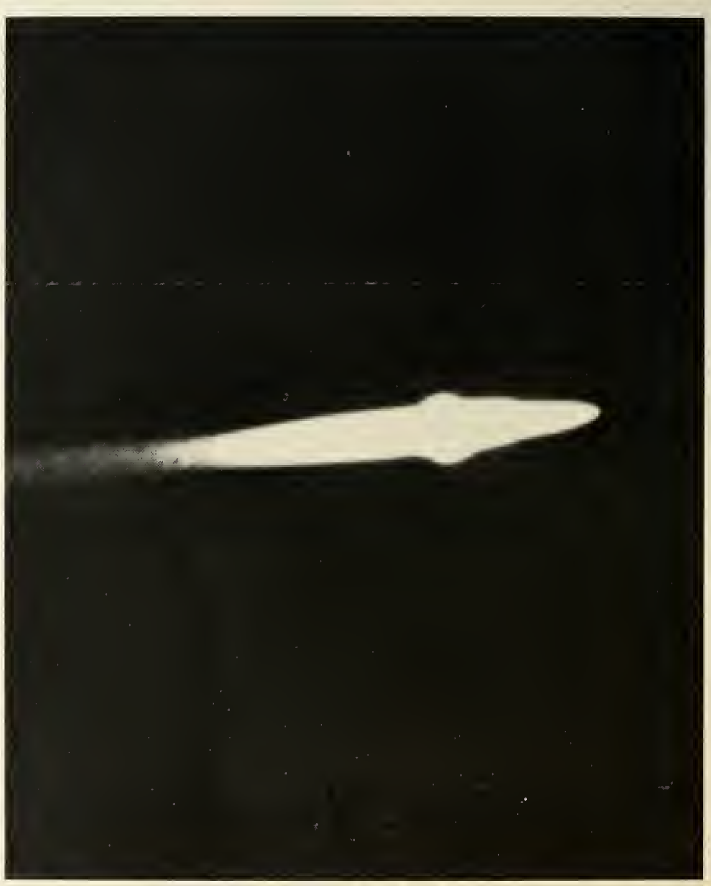
Generally, a short nozzle is most effective at sea level, and at higher altitudes a larger nozzle is more efficient. In most rocket designs, a trade-off somewhere between the optimum levels is chosen.

Hsia said his design permits an effective change in the nozzle expansion ratio as the vehicle ascends. At sea level, all of the air ports are opened and, "in effect, you get a short nozzle." As the vehicle ascends and some of the ports are closed "then it works like a long nozzle. So you get a significantly more efficient design."

UTC has tested the technique in several small-scale motors up to the 700-lb.-thrust level, all with company funding. A patent for the design is now pending.

Although the company will not comment, it has presumably proposed use of the technique to uprate the *Titan III-C.*

The system was proposed to the Army for the first stage of the *Pershing* missile and UTC has made presentations to other agencies. ■



Sprint Glows During Test Flight at WSMR

Army's Sprint anti-missile missile in flight test at White Sands Missile Range, N.M. Photo, recently released for the first time, shows second stage heated to incandescence by air friction. Bulges are causd by guidance fins on rear of stage. Skin of the missile, being developed by the Martin Co., in places reaches temperatures higher than those inside its motors.

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General Electric RTV silicone rubber secures Mariner's 28,224 solar cells

The job was formidable. Jet Propulsion Laboratory engineers needed a temperature-proof bonding agent to mount 28,224 solar cells in place on the four Mariner panels for its flight to Mars. JPL chose General Electric's flexible RTV-40 silicone rubber adhesive because it met design requirements: long-term resistance to environmental stresses from —392°F to 212°F. Did RTV-40 do its job? After many months in space and 21 spectacular close-ups of the Martian surface, we're inclined to say it did.

PROTECTION FROM DIRECT FLAME in fire areas is practical with silicone rubber. The jet engine oil ank shown here was coated with General Electric RTV-577 silicone rubber, exposed to a 2000°F lame for 16 minutes with no oil leakage or spillage during or after the flame exposure. Coated areas were still completely covered.

NEW TEMPERATURE-RESISTANT COATING on wings and fuselage of North American's XB-70 No. 2 contains General Electric silicone resins. The new silicone coating stays flexible at low temperatures, clings tenaciously to the substrate when the structure flexes in flight. It withstands heat too — up to 600°F at Mach 3.

WINDOW SEALS ON NASA'S APOLLO must withstand weight loss in vacuum, be non-toxic, perform uniformly in alternating hot and cold. After testing 14 high performance elastomers, North American Space Division used G-E RTV-560 silicone rubber as the sealant. RTV-560 retains high flexibility down to —160°F, meets non-flexible compression requirements down to —200°F.

For a free sample and more information about General Electric RTV ilicone rubbers, greases, fluids, etc., write to us on your letterhead, describing your application. Write Section 03190, Silicone Products Department, General Electric Company, Waterford, New York 12188.

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Area Correlation Tracker Demonstrated

Martin Co. system has primary application in guidance of launch-and-leave missiles; other uses include star-field tracking, terminal guidance for lunar landings

AN OPERATING MODEL of a passive homing system employing area optical-image correlation for aerospace guidance applications has been successfully demonstrated by scientists at Martin-Orlando.

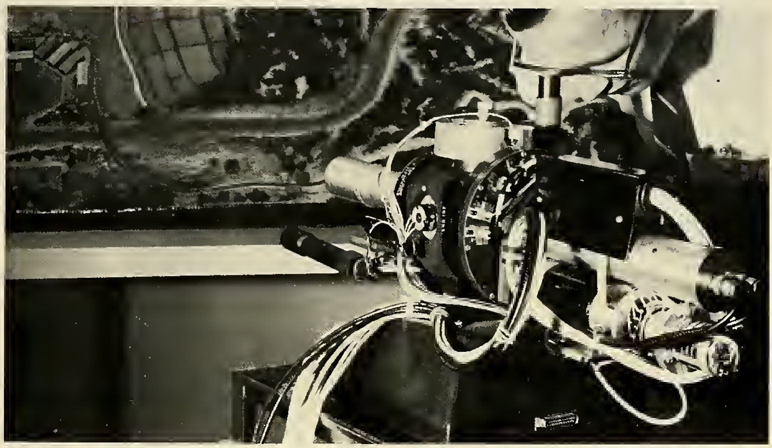
The area correlation tracker (ACT) a prototype pattern-recognition system, has been shown in both laboratory and captive flight tests capable of locking on and tracking low-contrast target areas compatible with a variety of guidance requirements.

Reportedly, the system can fit a wide variety of possible applications, according to Dr. Lamar Harmon, task leader of the tracker development. Of primary importance today, he pointed out, is use for guidance of stand-off, launch-and-leave, tactical missiles. But other possibilities, as well, offer potential. ACT could be used, for example, in satellite and space systems to track star-field patterns (as opposed to single stars) for drift-free angular reference in space missions. It could also serve as the terminal guidance system for lunar landing to home on a predetermined site on the Moon's surface.

Configuration—Packaged in a 6-in.-dia. configuration, ACT can be fitted in practically any small missile system, developers disclosed. With further refinement, it could be made to fit into a 4-in.-dia. package, Harmon said.

ACT is made up of a 3-axis gimballed optical system, magnetic memory, correlation data processing and control logic circuits, and tracker servos. In aircraft operation, the unit acts on pilot command to commit to memory optical information scanned from the scene to which it is aimed. A photo-sensor senses total energy received in the scanning cycle and produces a continuous video signal corresponding to the optical appearance of the scene during the scan.

The video signal is amplified and processed to yield a signal which can be compared scan-by-scan with the stored information. Controller logic is used to determine how much the target scene has shifted in pitch, yaw and roll. These shift error signals are used to drive the tracker optics.



Operation of Martin's prototype Area Correlation Tracker has been successfully demonstrated in laboratory and flight-operated to show tracking capability during range closure.

The accuracy of the scanning technique is independent of the size and number of contrast regions observed. However, scene misalignment that can be tolerated by the scanner without losing correlation entirely is somewhat dependent on the size of the contrast regions. The larger the regions in the field of view, the larger the misalignment and permissible boresight error that can be tolerated without losing lock-on.

Without optimization, the prototype correlator has a demonstrated error-signal generation accuracy of a very small percentage of the field of view.

Role uncertain—Although the company-funded development has not been tied to any particular applications, emphasis has been given to ACT's possible role in air-to-ground tactical missile guidance. Martin developers feel that the technique offers several advantages over conventional-approach pilot-controlled missile guidance.

The principal advantage of the passive homing guidance is that it gives the launching aircraft a stand-off launch-and-leave capability. With the ACT system, the pilot aims the missile at the target area, triggers a memory signal which causes the target "picture" to be automatically memorized, and then launches the missile. The aircraft is immediately free to take evasive action, select another target, or go home, leaving the missile to home in on the target without further external command, the firm says.

A "true" correlator—The Martin developers describe ACT as a true area correlator in that it continuously compares a currently scanned scene with a computer-memorized scene. It does not require a point target that contrasts sharply with its background; in fact, the system uses background information for tracking. The ACT homes on the general area pattern and automatically compensates for pattern "growth" during firing-run closure.

Area correlation tracking has some distinct advantages over the more conventional point or contour trackers which require single objects on which to home, Martin engineers claim. Its principal advantage lies in the ability of the system to home on an area which does not contain a specific high-contrast target such as a bridge or tank. This capability is particularly valuable against primary targets hidden by natural or artificial cover, such as troops dispersed in a wooded area or camouflaged installations or artillery. ■

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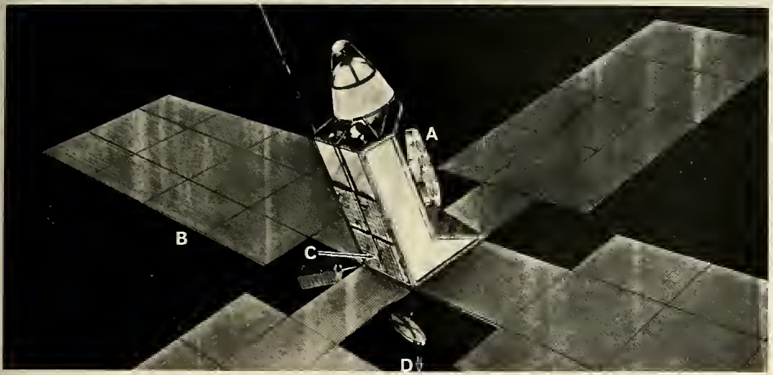
Ion Devices Move Toward Useful Space Applications

by Rex Pay



Hughes concept of solar-electrical propelled spacecraft for Mars orbiter/lander uses 10 ion engines powered by 48kw from solar panels. A—Propellant storage and thrustors. B—Solar power conversion. C—Power conditioning. D—Solar power source.

San Diego, Calif.—Use of electric power to propel U.S. spacecraft started in September, 1965, when an electrothermal thrustor adjusted the velocity of a *Vela* nuclear detection satellite. Further use of such thrustors is planned, and mission studies and reliability tests are speeding the application of ion propulsion to station-keeping of manned and unmanned satellites, and to unmanned deep-space probes.

Details of the advances electrical propulsion is making toward useful application were released here recently at the Fifth Electric Propulsion Conference of the American Institute of Aeronautics and Astronautics. The meeting provided a notably practical assembly of data on what had previously tended to be a largely speculative subject.

Dr. Ernst Stuhlinger, who has been associated with chemical propulsion development since Germany's World War II *V-2* rocket, told M/R that electric propulsion has now been proven much more feasible than chemical rocket programs were at their inception.

Heated gas—In the *Vela* type of thruster, or resistojet, cold gas is passed through an electric heating coil. TRW Systems Group used a 90-watt heater to raise by 50% the specific impulse of a nitrogen thrustor on *Velas 5* and *6*, launched by an *Atlas-Agena* in July, 1965. TRW engineers report that the result has been a major gain in maneuvering capability, desirable because of the increase in operating life shown by this series of satellites.

A resistojet with a power of 3 kw has been tested for 25 hours by Marquardt Corp. for the Air Force, and plans are currently being made for a 1,000-hour test.

Resistojets have also been selected by Douglas Aircraft Co. in a preliminary evaluation of station-keeping and stability control for NASA's *Manned Orbiting Research Laboratory*.

MORL is conceived as a 6-9 man vehicle for launching by a *Saturn IB* early in 1972. In orbit the 260-in.-dia. vehicle would be 44.2 ft. long and weigh 30,000 lbs. This weight would increase to 100,000 lbs. when a full complement of *Apollo* resupply vehicles was attached.

Use of an 11-kw radio-isotope-fueled Brayton cycle is anticipated, and both resistojets and radioisotope thustors appear feasible for long-term missions. Resistojets were selected as most promising for this application because they have been in development and testing for several years.

Low-thrust—Development of low-thrust ion engines was described by Hughes Aircraft Co., NASA's Lewis Research Center and Electro-Optical Systems, Inc. These would be used for station-keeping in synchronous communications satellites, weather satellites, and decoy satellites. First NASA flight of this type of ion engine is expected in 1968 on an *Applications Technology Satellite*, where it will be used for east-west station-keeping. The interaction of the thrustor with communications and attitude control systems will be watched closely, for future satellite and interplanetary probe design.

One of the most comprehensive studies of the feasibility of applying ion engines to spacecraft was described at the meeting by Jerry P. Mullin of NASA's Office of Advanced Research and Technology. This was a joint NASA /Air Force study involving Jet Propulsion Laboratory, NASA-Lewis, Hughes Aircraft Co., and EOS. JPL/Hughes studies of spacecraft were carried into the detail of a Mars mission Phase 1 study. Lightweight, large-area solar panels were projected to power the engines.

Reviewing the studies, Mullin concluded that "we now have an existing body of technology, and solar electric propulsion looks extremely good for certain classes of interplanetary applications. There should be interest in these systems for missions that are currently under study."

Studies ended—The joint studies have now been concluded. The NASA and AF missions call for divergent lines of development. OART is continuing to fund JPL studies for development of a methodology for mission analysis of Solar Electric-Propelled Spacecraft (SEPS). NASA-Lewis is also carrying out further studies in this area. The space agency's Marshall Space Flight Center and Office of Space Sciences and Applications are funding still other investigations.

A preliminary look has been given to the characteristics of a Jupiter mission carried out with solar-electric or nuclear-electric propulsion. This study at JPL for an 800-day mission in 1971 shows that where the nuclear-powered spacecraft can arrive at Jupiter with a very low approach velocity, the solar-electric-powered spacecraft arrives at a speed comparable to that of a chemically-powered mission.

Other potential missions for an SEP spacecraft are a Mercury trip, a solar probe, and an out-of-the-ecliptic flight. The latter is of interest not only scientifically but also as a good engineering test of the solar-electric propulsion concept, as the probe would stay above the Earth but move up out of the plane of the ecliptic. This would make engineering tests of the interaction of the ion engine with other systems simpler.

New **studies**—The next series of studies are likely to push forward into greater detail in spacecraft design, moving away from feasibility studies and toward optimization.

Among the questions to be resolved are whether large ion beams and solar arrays result in a spacecraft which builds up a static charge on itself, what sort of field develops, and whether the plasma beam can be used to expel excess charge.

Another area of importance is the possibility of beam divergence and impingement on different areas of the spacecraft, such as optical attitude sensors.

The high currents in the engine system may produce radio-frequency interference. There may be a problem with up-link communications, so the requirements for antenna arrays and on-board receiver amplification will be studied.

New concepts in power conditioning that are reaching the hardware stage will be examined. The interplanetary solar-powered spacecraft produces some unique conditioning requirements—although the solar power input drops as the spacecraft moves away from the Sun, the solar cells become more efficient due to the drop in temperature, and the optimum load varies.

Advantages—The advantages offered by solar-electric propulsion, however, make these investigations well worthwhile. Hughes studies carried out for JPL compared an SEP spacecraft with an all-chemical spacecraft, both to be launched on a Mars mission in 1971. Results showed that the electrical spacecraft can put almost twice as much useful weight into Mars orbit.

The Hughes study predicts total program cost for the 1971 solar-electric-propelled spacecraft as $375.9 million, compared with $194.5 million for all-chemical spacecraft, not including the costs of the scientific payload and lander. The costs of the scientific payloads for the two spacecraft are projected as $626 million and $163 million, respectively. However, although total program cost of the SEP spacecraft is about twice that of an all-chemical spacecraft, the cost per pound of scientific payload in Mars orbit is about one-half.

The Hughes study considered a spacecraft with a solar power of 48 kw 21-Earth and 10 mercury-bombardment engines, eight operating and two in stand-by. Specific impulse was 4,000 sec. and propellant weight 1,600 lbs. The thrustors, their controls, feed system, and propellant tanks were integrated into one unit located externally on the prime spacecraft structure. The unit is attached to the spacecraft bus by means of a translation mechanism that allows alignment of the thrust vector with the spacecraft's center of gravity, minimizing disturbance torques.

Jettisoned—To minimize the retro system for entering into Mars orbit, the electric propulsion unit and many of the solar panels are jettisoned on final approach to the planet.

A similar design was also used for a spacecraft of 10 kw power launched by an *Atlas-Centaur*. This would use six ion engines. For both spacecraft the lightweight large-area solar-cell arrays were designed by Boeing Co. Hughes, working under an Air Force contract, has been developing a flexible solar array expected to provide 20 kw of power for a spacecraft launched by *Atlas-Centaur*. ■

Manned Asteroid Fly-by Advocated for 1974-75

Cocoa Beach, Fla.—A 527-day manned asteroid fly-by mission has been suggested at the Space Research Missions session of the Third Space Congress of the Canaveral Council of Technical Societies.

Eugene A. Smith of Northrop Space Laboratories outlined a flight that would start with a May 3, 1974, launch, include a fly-by of the asteroid Eros Jan. 28, 1975, and end with an Earth landing Oct. 12, 1975.

Dates are critical, with only a 30-day launch window available, he said. Although Eros is in a favorable position every seven years, a launch in the 1980's would interfere with the higher-priority Mars and Venus launches.

The asteroid fly-by would use a single uprated *Saturn V* launch vehicle and a six-man *Apollo* spacecraft, he said.

Dog-Carrying Cosmos Includes Many Experiments

THE SOVIETS HAVE disclosed that the orbiting *Cosmos 110* Satellite containing two dogs also carries a variety of biological experiments similar to those of the U.S. *Biosatellite* project.

A Tass release said the prime experiment is a study of the dogs' heart and circulatory systems. Electrode sensors are implanted in the animals' peripheral nerves to study the activity of the brain in regulating the circulatory system.

The two dogs, Veterok and Ugolek (principal experimental animal and control animal respectively), are in two separate capsules in which they can assume different positions, the Soviet said. However, they are clad in corset-like restraining garments which fix them in the capsule and connect the sensors and food delivery lines.

Sources of the Tass article were Academician Norair Sisakyan, specialist Vladimir Pravetskiy, and Cosmonaut Boris Yegorov, who also reported that the experiment was proceeding successfully.

Direct feeding—Food is being administered the animals in paste-form from plastic containers and is being placed directly in the dogs' stomachs through gastrotoms, or surgical openings.

Life support system for *Cosmos 110* is apparently a modification of that used in Soviet missions orbiting dogs in August, 1960, and March, 1961. It is equipped with an oxygen regenerating system, fans, refuse disposal, telemetry and systems and an automatic system for the administration of drugs. Presumably Veterok is receiving the drugs believed to be for radiation protection in the high-intensity radiation zone in which the satellite is orbiting, while Ugolek is unprotected.

Radiation studies also include a number of biological and physical dosimeters throughout the satellite, and verification studies of the methods used in the calculation of the ship's protection.

Other experiments—In addition to the dogs, the other biological specimens aboard include strains of yeasts, samples and blood serums, protein preparations, certain varieties of chlorella and lysogenic bacteria.

The Soviets reportedly are receiving telemetered information on the dogs' arterial pressure, heart "biocurrents," as the Soviets put it, pulse in the carotid artery, mechanical work of the heart and respiration rate. ■

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The Industry Week

Mergers and Acquisitions

General Aniline & Film Corp., New York City, has proposed a merger with Nopco Chemical Co., Newark, N.J. The offer calls for an exchange of stock valued at about $56 million. Nopco disclosed that a similar offer from General Aniline last fall was rejected. The firm is also conducting acquisition talks with Burkart-Schier Chemical Co., Chattanooga, Tenn. . . . *Nytronics, Inc., Berkeley Heights, N.J., will take over working control of Burnell & Co., Pelham, N.Y., under a conditional contract announced recently. Burnell, producer of electronic filter networks, will sell 225,000 shares of its stock to Nyvestor Corp., a Nytronics subsidiary, at a below-market price. Holders have a two-year option for exchange of an additional 111,375 shares of Burnell for Nytronics stock.* . . . Teledyne, Inc., Hawthorne, Calif., has reached an agreement to purchase Vasco Metals Corp., Latrobe, Pa. Plans call for exchange of one share of a new class of Teledyne preferred stock for three shares of Vasco common stock. The merger is subject to approval of directors and stockholders of both firms. . . . *Electrada Corp., Culver City, Calif., has acquired the assets of Sargent Engineering Co. and Sargent of Huntington Park from A.J. Industries, Inc. Sargent of Huntington Park produces hydraulic and mechanical actuators.*

New Activities

Honeywell, Inc., has reorganized its two aerospace facilities in Minneapolis and St. Petersburg, Fla., into a single Aeronautical Div. Director will be W. T. Noll, vice president and general manager. Honeywell's Systems and Research Div., Minneapolis, has been expanded to include all of the firm's research, development and technological activities devoted to advanced military and space products and systems. . . . *Consolidated Engineering Technology Corp. has been formed in Palo Alto, Calif., as a subsidiary of Technology, Inc., Dayton, Ohio. The new firm will do R&D work on gas dynamics, solid rocket technology and fluid mechanics. It will also pursue international joint ventures in India. Rao S. Channapragada is president of the new company.* . . . TRW Systems, Redondo Beach, Calif., has formed four new product line divisions and a central systems laboratories unit. The new organizational units are: Systems Engineering and Integration Div., Space Vehicles Div., Power Systems Div., Electronic Systems Div., and Systems Laboratories. . . . *Epsco, Inc., Westwood, Mass., has formed a communications products department to extend data handling skills into the area of radio frequency devices.* . . . Hewlett-Packard Co., Palo Alto, Calif., has consolidated its advanced research and development activities into a new organization, HP Laboratories. The unit is headed by Bernard M. Oliver, vice president of R&D. . . . *The MITRE Corp., Bedford, Mass., has created two new departments by splitting the former radar systems and techniques department into the radar design department and the radar technology department.*

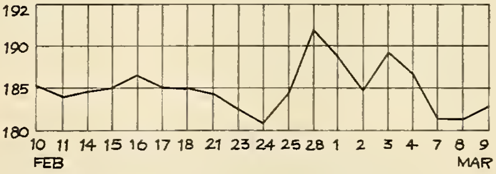
International

Sheffield Corp., Dayton, Ohio, has signed an agreement with The Newall Machine Tool Co., Ltd., Peterborough, England, giving the firm license to manufacture and sell the Newall jig boring and milling machine in the U.S. Sheffield also has distribution rights to the complete line of Newall jig borers in North and South America. . . . *Goodyear International Corp., Cleveland, plans to build a factory in Northern Ireland near Belfast and to expand plants in England and Scotland. Total cost will be about $29 million.*

Facility Expansions

McDonnell Aircraft Corp., St. Louis, has conditionally agreed to purchase 228 acres of land adjacent to the Orange County Airport near Los Angeles from Irvine Industrial Complex, Inc. Future use of the land was not disclosed. . . . *Trimpot Div. of Bourns, Inc., Riverside, Calif., has completed a $1.5-million manufacturing facility near Ames, Iowa. The plant will be used for increased production of miniature electronic products.* . . . Polytronics Laboratories, Inc., a subsidiary of Vitro Corp. of America, will move to a new location in Silver Spring, Md., this spring. The firm produces radio equipment. . . . *Fairchild Semiconductor Div. has begun construction of new research and development facilities in Mountain View, Calif. The addition will double the size of its laboratory to 200,000 sq. ft.* . . . The Society of Plastics Engineers has purchased property in Greenwich, Conn., for the site of its future headquarters. . . . *Beach Aircraft Corp.'s Aerospace Div. is expanding its manufacturing facility in Boulder, Colo. The complex, totaling 41,000 sq. ft. of manufacturing area, is expected to be completed in April.* . . . Spectrol Electronics Corp., Los Angeles, has consolidated its West Coast facilities in a new plant in the City of Industry, Calif. . . . *Robinson-Halpern Corp., West Conshocken, Pa., is expanding its main plant by 50%. The company, formerly the Instruments & Systems Div. of International Resistance Corp., manufactures pressure and displacement instrumentation.*

Missile/Space Stock Index



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AIR FORCE

$7,189,072—**North American Aviation, Inc.,** Anaheim, Calif., to make components for an improved *Minuteman* guidance system and $5,902,991 to produce maintenance equipment for the *Minuteman* program.

$3,121,004—**Cutler-Hammer, Inc.,** Deer Park, N.Y., for reconnaissance systems spare parts.

$2,200,000—**International Business Machines Corp.,** Rockville, Md., for a computer system and support services to "referee" battle simulations called AFWET (Air Force Weapons Effectiveness Testing).

$2,090,000—**United Aircraft Corp.,** West Palm Beach, Fla., for work on a development program for high-performance rocket engines.

$2,010,233—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for *Agena* rocket launch services for 1966 at Cocoa Beach, Fla.

$1,550,513—**Hycon Manufacturing Co.,** Monrovia, Calif., for KS-72 aerial reconnaissance camera systems and spares.

$738,300—**Philco Corp.,** Philadelphia, to provide microminiature digital data transmission equipment for use in the missile tracking facilities.

$550,000—**Cornell University,** Ithaca, N.Y., for two-year investigation of new electrophysical device concepts for generation of microwaves.

$379,520—**General Dynamics Corp.,** Convair Div., San Diego, Calif., for industrial facilities to support the *Atlas* standard launch vehicle program.

$348,565—**Bendix Corp.,** Ann Arbor, Mich., for R&D for feasibility program of deep penetrating radar reflectors.

$332,000—**Aerojet-General Corp.,** El Monte, Calif., for eight-month effort for modification of existing equipment designed for *Titan I* and *Atlas* sites to *Minuteman* specification at Vandenberg, Grand Forks and Malmstrom Air Force Bases.

$307,098—**Lear Siegler, Inc.,** Electronic Instrument Div., Anaheim, Calif., for universal telemetry decommutation system.

$224,700—**General Applied Science Laboratories,** Westbury, N.Y., for a feasibility experiment for aerothermodynamic ground-testing of ramjet components.

$84,238—**Goodyear Aerospace Corp.,** Akron, Ohio, for phase 1 design, fabrication and orbital testing of a space structure.

$45,526—**Sylvania Electric Products, Inc.,** Waltham, Mass., to pursue the study of communication "black outs" experienced by space vehicles re-entering the Earth's atmosphere.

ARMY

$10,000,000—**Philco Corp.,** Philadelphia, addition to letter contract for an integrated wide-band communications system in Southeast Asia, with total commitment now $26 million for system.

$6,196,213—**Union Carbide Corp.,** Chemway, N.C., for radio set components.

$2,000,000—**Martin Co.,** Orlando, Fla., for production of Army ordnance items.

$645,087—**Collins Radio Co.,** Dallas, for additional work on Dazzle radar.

$215,000—**Stanford University,** Stanford, Calif., for 24-month research study of electronic warfare and electronic countermeasures.

$94,418—**Boeing Co.,** Aerospace Div., Seattle, Wash., for four-month research for ARPA dispersed hard-point defense study.

$79,400—**Rocket Power, Inc.,** Mesa, Ariz., for sounding vehicle rocket booster motors.

$31,741—**Kaman Aircraft Corp.,** Daman Nuclear Div., Colorado Springs, Colo., for technical services in connection with projects Ferris Wheel and *Nike-X*.

$28,026—**Brown Engineering Co.,** Huntsville, Ala., for R&D effort for engineering design studies, development analysis, program valuation and illustrative work on the *Nike-X* missile system.

NAVY

$26,550,000—**Lockheed Aircraft Corp.,** Burbank, Calif., for work on the *Poseidon* missile system.

$14,283,900—**Farmers Tool & Supply Corp.,** Denver, Colo., to manufacture 2.75-in. rocket components.

$12,105,000—**Marquardt Corp.,** Van Nuys, Calif., to manufacture 2.75-in. rocket components in Ogden, Utah.

$7,801,000—**American Electric, Inc.,** Paramount, Calif., to manufacture 2.75-in. rocket components.

$6,792,250—**Hoffman Electronics Corp.,** El Monte, Calif., to manufacture 2.75-in. rocket components.

$5,985,250—**Columbus Milpar Manufacturing Co.,** Columbus, Ohio, to manufacture 2.75-in. rocket components.

$4,281,572—**Magnavox Co.,** Fort Wayne, Ind., for sonobuoys.

$2,204,712—**Atlantic Research Corp.,** Alexandria, Va., fixed-price contract for rocket motors for *Terrier* missiles.

$1,238,237—**Canadian Commercial Corp.,** Washington, D.C., for 2.75-in. rocket motor propellant.

$41,020—**Fawn Plastics Co.,** Timonium, Md., for *Zuni* inhibitors.

NASA

$55,500—**Booz-Allen Applied Research, Inc.,** Bethesda, Md., from Goddard Space Flight Center for reliability and quality assurance studies for the *Orbiting Astronomical Observatory* spacecraft.

$52,516—**Dynatech Corp.,** Cambridge, Mass., from Headquarters for study of an electrodynamic vapor absorption refrigerator for weightless environment.

$47,892—**Kaman Aircraft Corp.,** Avidyne Div., Burlington, Mass., from Ames Research Center for a study of thermal trajectory dynamics and guidance control concepts for lifting re-entry vehicles.

$41,276—**Boeing Co.,** Aerospace Group, Seattle, Wash., from Ames Research Center for thermal protection system study.

$30,535—**Geo Space Systems,** Melbourne, Fla., from Goddard Space Flight Center for low-gain yagi command antenna.

$19,743—**Lockheed Missiles and Space Co.,** Huntsville, Ala., from Marshall Space Flight Center for research on stability of periodic motions.

Dynair Electronics, Inc., San Diego, Calif., from Kennedy Space Flight Center to supply video distribution equipment for installation at *Apollo* Complex 39. Amount not disclosed.

INDUSTRY

$2,611,700—**Natkin & Co.,** Kansas City, Mo., fron **Catalytic Construction Co.,** Philadelphia, fo the fabrication, installation, cleaning, and testing of the RP-1, LOX, LH2, and pneumati systems for the *Apollo/Saturn V* launch vehicl at Complex 39B.

$925,768—**Straza Industries,** El Cajon, Calif., fron **Catalytic Construction Co.,** Philadelphia, fo the fabrication, installation, cleaning, and testing of all vacuum jacketed piping necessary t transfer liquid propellants from storage facilities to the *Apollo/Saturn V* launch vehicle a Complex 39B.

$341,662—**Space Ordnance Systems, Inc.,** El Segundo, Calif., from **Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for an ordnance system to be used on the Luna Excursion Module. Also, $115,000 from **Nort American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., for separation system for use in the emergency escap system of *Apollo* spacecraft.

$229,419—**U.S. Gauge Co.,** Sellersville, Pa., fro **Martin Co.,** Orlando Div., Orlando, Fla., f pressure gauges.

$52,000—**Aluminum Co. of America,** Verno Calif., from **Boeing Co.,** Seattle, Wash., f base castings used for electronic cabinets f the *Minuteman* ICBM program.

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Please write in full confidence, including salary requirements, to: Mr. D. M. Hill, Professional Placement, Room 1111-L, Apollo Support Dept., General Electric Company, P.O. Box 2500, Daytona Beach, Fla. 32015.

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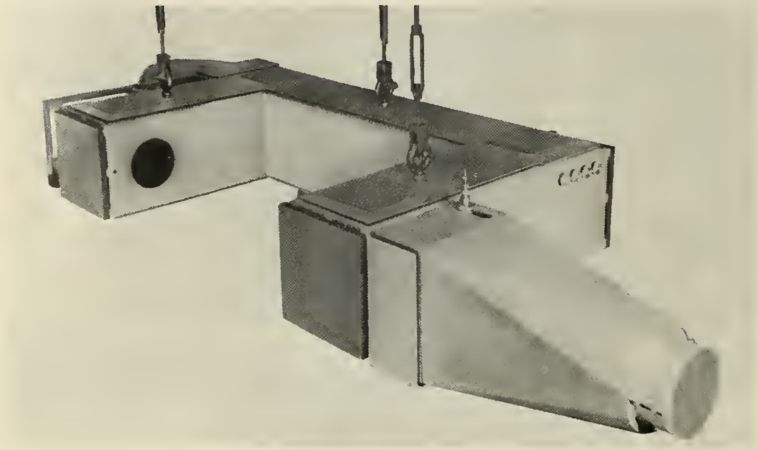

New Product of the Week:

Interferometric Systems

A group of Mach-Zehnder interferometric systems with optical apertures from 2 to 10 in. has been announced by Intertech Corp.

The instruments can be used where the determination of complex density fields cannot be achieved by conventional instrument probes and in such fields as electron density measurement in plasma physics and photoelasticity.

The assembly will produce interference fringes at the screen of ¼ wave length or better, and exhibits exceptional stability over long periods of time, the firm says. They can be easily adjusted by hand or remote control and can be used for Schlieren and Shadow-Graph methods using simple attachments.

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Pressure Transfer Gauge

Seegers Instrument Co. has announced a series of pressure transfer inspection gauges, featuring solid metal fronts.

Accuracy is 0.10% FS for all three dial sizes of 8½-in., 12-in., and 16-in. panel mount. Dials, bourdons and movements are interchangeable. A valve and separate port permit easier, faster bleeding and/or flushing the firm says. LOX cleaning is available.

The instruments have a mechanical corrective action to compensate for temperature, gravity, buoyancy and perpendicularity. Readability is a full 310 degrees calibration.

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Wideband FM Receiver

A series of wideband FM diversity receivers covering a range of 500 MHz to 16 GHz is available from RHG Electronics Laboratory, Inc.

Model FMR300A12 features basebands up to 15MHz and IF bandwidths to 60MHz. RF range is 890 to 960 MHz tunable, with image rejection of 60 db minimum. IF frequency of the unit is 70 MHz and IF bandwidth 30 MHz minimum. Linear discriminator bandwidth is ±15MHz and video bandwidth from 20 Hz to 12MHz.

Separate mixer-amplifier-discriminator chains with common local oscillator and video circuitry can provide automatic video switching at 50 microsecs or pre- and post-detection signal combining at switching speeds of 1 microsec.

Circle No. 153 on Subscriber Service Card

Differential Amplifier

A differential d-c amplifier that provides two individual outputs from a single input has been announced by Neff Instrument Corp.

Type 118-5 has two outputs transformer-isolated from each other and both isolated from the input. Input circuitry to the amplifier is differential and utilizes a guard shield. The outputs may be separately grounded. One channel of input data may be simultaneously recorded on two different types of recorders, or one output may be used for control purposes and at the same time observed or recorded on the second output.

The amplifier offers 10 selectable gain steps from 10 to 2,000. One output is 5v full scale at 10 ma; the other is 1 to 10v full scale at 10 ma. The unit will withstand common mode voltages up to 300v. Common mode rejection is 120 db from dc to 100 cps. Peak noise is less than 0.1% full scale.

Circle No. 154 on Subscriber Service Card

Temperature Test Chamber

A temperature test chamber for miniature electronic components has been developed by Cincinnati Sub-Zero Products.

Model U-100-4 has a temperature range adjustable from ambient to — 100°F; environmental temperatures are provided for testing of resistors.

The 4-cu.-ft. stainless steel chamber measures 20 x 20 x 18 in. A fin coil primary evaporator is located in the plenum area at the rear of the chamber. An 8-in.-dia. circulator minimizes temperature stratification. The assembly incorporates 500-watt air heaters for defrosting.

High-low pressure gauges provide visual indication of operation of both refrigeration systems. Temperature settings are maintained by an indicating controller. Electrical specifications are 230-60-1.

Circle No. 155 on Subscriber Service Card

Vibration Machine

L.A.B. Corp. has announced a servo-controlled reaction type vibration machine designed to produce constant g performance.

The Model RVHAC-30-300 utilizes adjustable steel eccentric weight elements controlled by oil pressure to vary the degree of table vibration. The machine vibrates both vertically and horizontally. Changes in direction of vibrations are made while the machine is at standstill. Acceleration levels as high as 10 g's can be applied to a mass load of 300 lbs. with a center of gravity 10 in. above the load mounting surface.

The load mounting surface is 30 sq. in. The machine's frequency range is from 5 to 60 cps.

The unit meets MIL-STD-353A specifications and can be employed for general purpose environmental testing.

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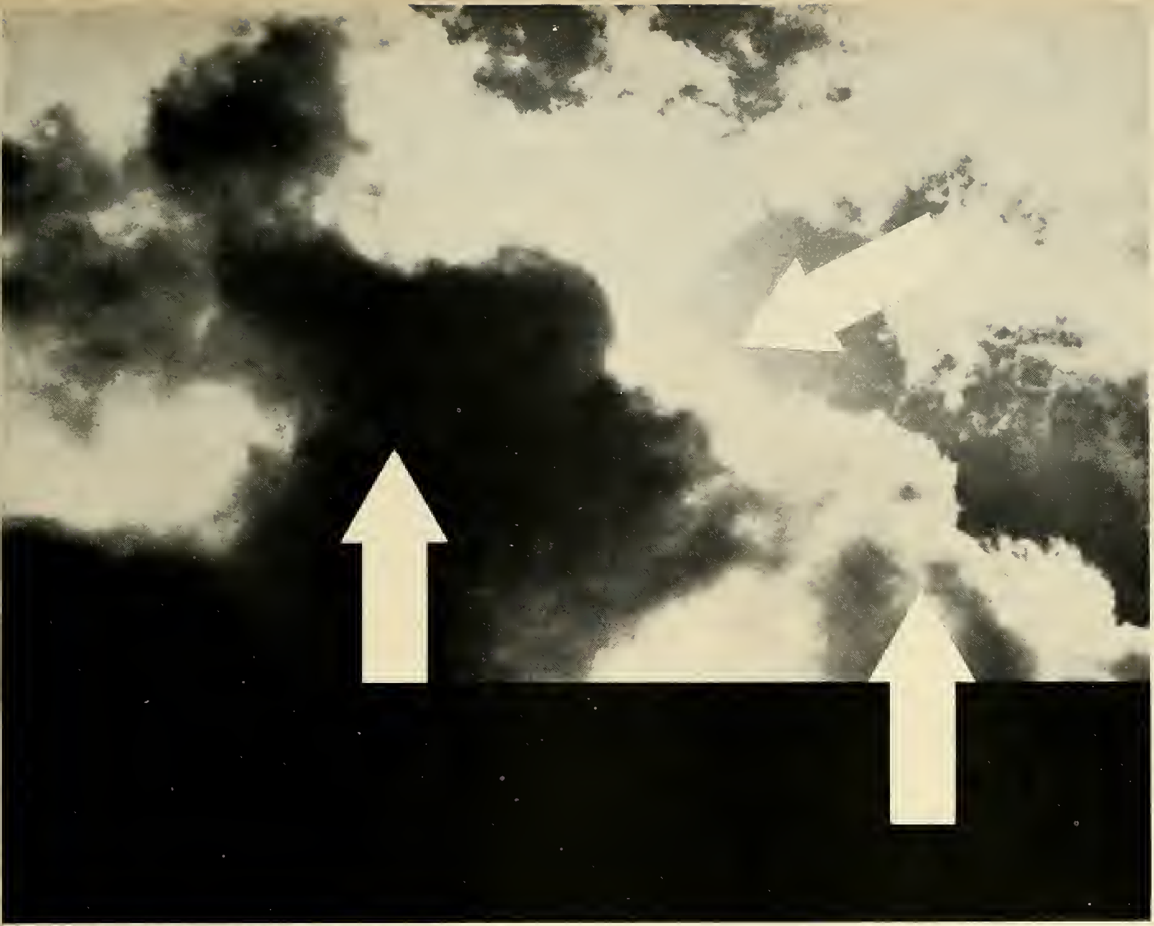

Major U.S. Air Force missiles are launched from the air, surface and underground.

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As part of its deep involvement with the Air Force in the development of major air, surface and underground-launched missiles, Boeing has advanced the state-of-the-art of missile propulsion systems, of electronic guidance and control technology, and of support systems.

Significant advances have also been made by Boeing in the integration of diverse system elements, including electronic systems. These Boeing-developed techniques fit missiles to their carriers, or to launch-control and support equipment, to form systems teams that work together in complete harmony and at extremely high levels of reliability.

Boeing has also built hundreds of advanced missile platform bombers and airborne launch-control systems. Boeing missile specialists have integrated two major Air Force missiles with their control and support systems. They have also helped the Air Force conduct the largest missile flight-test program in history.

At Boeing, more than 7,500 personnel are engaged in electronics research, design and manufacturing activities. They provide everything from advanced research to complete systems, including airborne launch-control systems and thousands of end items for missile systems. Electronics programs at Boeing include space vehicle flight programmers, command and control hardware, targeting digital computers, automatic landing systems, scanning and homing radar, electronic countermeasures, radar systems, communications.

This extremely broad and deep missile experience at Boeing is backed by intensive backgrounds in systems management, quality control and reliability engineering . . . a unique, broad-spectrum capability now being applied to the definition of a new air-to-surface attack missile system for the U.S. Air Force.

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names in the news

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Stanley A. Wainer: Elected a director of Wyle Laboratories. He is vice president of finance and secretary/treasurer of the company.

William F. Osborn: Named vice president of engineering and plant manager of Sigma Systems Corp. **William D. Jobe:** Appointed vice president of marketing.

John W. Rhinesmith: Appointed vice president of marketing for Simmonds Precision Products, Inc. He joined the company in 1964. Previously, he was a program development manager of the Autonetics Div. of North American Aviation, Inc.

C. R. Gates: Named vice president, international, of Northrop Corp. He succeeds **Lt. General Patrick W. Timberlake** (USAF, Ret.).

Dr. Anthony Kurtz: Elected president of Kulite Semiconductor Products, Inc. In addition to his new duties, he will continue to direct the company's research and development programs.

James E. Thornton: Named vice president of the technical staff of Control Data Corp. His responsibilities will include computer circuit and packaging technology and magnetic core memory design.

Frank F. Oddi: Elected a director and vice president of planning of National Co., Inc.

John A. Postley: Elected vice president of Informatics' Advanced Information Systems. He will be responsible for computer-based systems for government and industry.

James Francis Smith: Named vice president of sales and marketing for Clarostat Manufacturing, Co., Inc. He has served as a member of the board of directors of the Electronic Distributor Show Corp.

Robert T. Meek: Appointed vice president of Walworth Co. and general manager of Walworth Products Div. He will be in charge of division sales, manufacturing, engineering, industrial relations, purchasing, administrative methods and accounting activities.

Herbert S. Kindler: Named executive director of the Instrument Society of America (ISA). He holds patents in electronic potentiometry and mass flow measurement and has written a book entitled *Organizing the Technical Conference.*

Paul C. Berkey: Named president and general manager of LeFiell Manufacturing Co. **Clifford W. Hoffman** has been appointed executive vice president and treasurer.

William S. Baltz: Elected vice president of government electronics division of Admiral Corp. He has been vice president and general counsel for the corporation.

John L. Reynolds: Appointed vice president of marketing for C. A. Norgren Co. He was president of the National Standard Parts Association.

Daniel N. Schochet: Named vice president, general manager of Associated Testing Laboratories, Inc. Prior to joining the company, he served as a senior project engineer with Bogue Electric Corp.

James R. Ambrose: Appointed director of corporate technical planning for Philco Corp. He will be responsible for the development of plans for the firm's defense, space and industrial business, and for coordination and integration of the long-range plans of the five divisions which operate in these areas.

W. H. Steiner: Elected treasurer and controller of Hayes International Corp. He has held executive positions with Ford Motor Co. and Reynolds Metals Co.

Delmer C. Ports: Selected president of the Institute of Electrical and Electronics Engineers 1966 Aerospace and Electronic Systems Convention. He is vice president of the Jansky and Bailey Div. of Atlantic Research Corp.

Arthur C. Bustamante: Appointed controller and executive assistant to the president of Rezolin, Inc. Prior to joining the company, he was assistant controller, assistant secretary and director of personnel fo Kierulff Electronics.

Dr. Erwin Baumgarten: Named directo of the Institute of Naval Studies of th Center for Naval Analyses. He will be i charge of delineating and analyzing basi problems in strategy, technology, and geopolitics that are likely to affect the Nav of the future.

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

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MARCH

Seminar on Atmospheric Physics, sponsored by the American Institute of Physics, Shoreham Hotel, Washington, D.C., March 14.

Fourth Goddard Memorial Symposium, "Space Age in the Fiscal Year 2001," sponsored by the American Astronautical Society, Sheraton Park Hotel, Washington, D.C. March 15-16.

50th Anniversary Meeting of the Optical Society of America, Shoreham Hotel, Washington, D.C., March 15-18.

Fourth International Aerospace Instrumentation Symposium, sponsored by the Instrument Society of America, Cranfield, England, March 21-24.

International Convention, sponsored by the Institute of Electrical and Electronics Engineers, Coliseum & New York Hilton Hotel, New York City, March 21-25.

Second Annual Solar Energy Society Conference, Somerset Hotel, Boston, March 21-23.

American Chemical Society 151st National Meeting, Pittsburgh, March 22-31.

Conference on Neutron Cross-Section Technology, sponsored by the American Physical Society, Atomic Energy Commission, National Bureau of Standards and American Nuclear Society, Shoreham Hotel, Washington, D.C., March 22-24.

International Committee Meeting of the Aerospace Industries Assn., Statler Hilton Hotel, Washington, D.C., March 22-24.

1966 National Convention, Air Force Assn., Dallas, Tex., March 22-25.

Conference on Modern Methods of Weather Forecasting & Analysis, sponsored by the American Meteorological Society, University of Chicago, Chicago, March 23-25.

"Photo-Imaging Materials for Science and Industry," sponsored by the Society of Photographic Scientists and Engineers, Hotel Plaza, New York City, March 24-25.

Human Factors & Bioengineering Conference, sponsored by the American Society of Mechanical Engineers, International Inn, Washington, D.C., March 28-29.

Stepping Stones To Mars Meeting, sponsored by the American Institute of Aeronautics and Astronautics, American Astronautical Society, Baltimore, Md., March 28-30.

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Lives of Good Brave Men

THE DEATH which came to Astronauts Elliott See and Charles Bassett in the crash of their Northrop T-38 at the McDonnell Aircraft St. Louis plant seems a wasteful and tragically abrupt end to a future of shining promise—as did the earlier death of Astronaut Theodore Freeman in a Houston crash.

But consideration of all aspects of the tragedies indicates that these sacrifices were not in vain, that the three brilliant young men served their nation in a way which has gone unrecognized. This is of little consolation to those left behind; but acknowledgment of their contribution to the country's future may serve to soften grief.

Sooner or later, a similar tragedy can touch the space program itself. Despite the most strenuous safety measures, including a traceability program which does much to insure the integrity of space hardware, the day may come when disaster strikes the *Gemini* or *Apollo* projects, taking the lives of one or more of the nation's astronauts on the launch pad, in space or on the lunar surface.

By emphasizing the everyday risk taken by all the astronauts in the course of training, the deaths of Capt. Freeman, Mr. See and Maj. Bassett have almost certainly lessened the outcry against the space program in the event of similar losses during space operations.

Each time an astronaut steps into a military jet aircraft, he is running a risk perceptibly greater than that he takes in space. The National Aeronautics and Space Administration takes the greatest of care to assure that manned spacecraft launches are as safe as the best engineering talent in the nation can make them. A launch atop a *Titan II*, hazardous as it may be, cannot compare with the danger inherent in groping through low fog for an elusive runway in a jet aircraft.

This is not to deprecate the risk involved in a space launch. But the military fliers and civilian test pilots in the space program are no strangers to danger. They have faced it many times. They would be the last to want a delay or cancellation of manned space projects in event of a tragedy.

By lessening that possibility, the astronauts who lie in Arlington have done a service to their comrades and to their nation.

THIS MAY BE THE TIME to take a close look at the early tragedies in aviation to see what impact similar disasters in the space program may have on press and public opinion.

The first aviator killed was Lt. Thomas E. Selfridge, who died Sept. 17, 1908, at Ft. Myer, Va., in a crash which seriously injured Orville Wright.

The Army was quick to emphasize the importance of the aviation program in the face of the tragedy. "Of course we deplore the accident," said the head of the Signal Office of the War Department, "but no one who saw the flights of the last four days at Ft. Myer could doubt for an instant that the problem of aerial navigation was solved . . . these accidents and setbacks will occur as they occur in every new field of endeavor, but the main problem has been demonstrated."

Gen. Luke E. Wright, Secretary of War, stated promptly: "It is a very sad happening and one to be deeply regretted. (But) I see no reason why this accident should give any serious setback to the experiments in aeronautics being made by the Army."

Despite widespread coverage of the crash, the Army's prompt explanation of the importance of the project was reflected in the editorial comment on the accident.

The Washington *Evening Star* said the following day: "Whatever is the verdict (on the cause of the accident) there is no question in the minds of Army officers that the flying machine experiment will be continued and that the ultimate development of the machine will be successful."

The *Washington Post* said: "The death of Lt. Selfridge and the serious injury of Mr. Wright is a grim reminder that man's conquest of the air is not to be achieved without danger and death. . . . Men will not be daunted, however, in their efforts to fly. They will learn something from this accident, thus turning even misfortune to account in the tireless quest for the secret of aviation."

The *New York Times* took the same approach.

There is an important lesson in this for NASA. If disaster strikes the space program, it will not be in the comparative isolation of a Ft. Myer in a world of limited communications. Chances are it will be within the sight or hearing of millions tuned in throughout the world. NASA spokesmen must be well drilled in their role to overcome the widespread shock of the tragedy. History shows it can be done. To prepare for such an eventuality is not to raise a spectre; it is the same commonsense precaution which calls for the training of airline stewardesses in emergency procedures.

Commenting on the deaths of two early-day aviators, the *Los Angeles Times* said: "Aviation is a great and waiting step in human progress and without its practicalization the destiny of humanity will never be fulfilled. . . . This high development cannot be attained without pioneers, and while the science of flight is in a state of experimentation many lives of good brave men will be sacrificed."

Whatever lies in the future, that valedictory is as fitting for the first three astronauts to die in the service of the country as it was for John B. Moisant and Archie Hoxey in the year 1911.

William J. Coughlin

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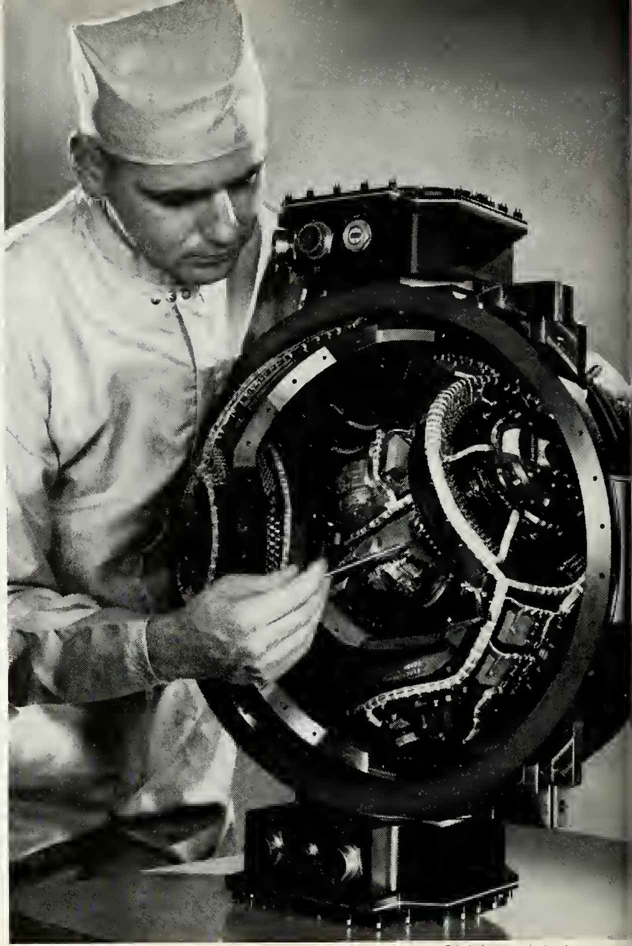

Technician at The Bendix Corporation's Eclipse-Pioneer Division points to inner gimbal of Saturn rocket stabilized platform, which includes components cleaned by Genesolv-D.

The reliability of critical aerospace assemblies depends on scrupulous cleanliness as well as on precision tolerances and finishes. That's why Eclipse-Pioneer uses Allied Chemical's Genesolv-D Electronic Grade Solvent for this critical cleaning assignment.

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3. It's nonflammable, nonexplosive, relatively nontoxic.

4. Selectively cleans metals, plastics, elastomer and paint or varnish surfaces, with little or no solvent action on base materials.

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These gyros are used in each stabilized platform, which includes components cleaned by Genesolv-D.

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MARCH 21, 1966

missiles and rockets

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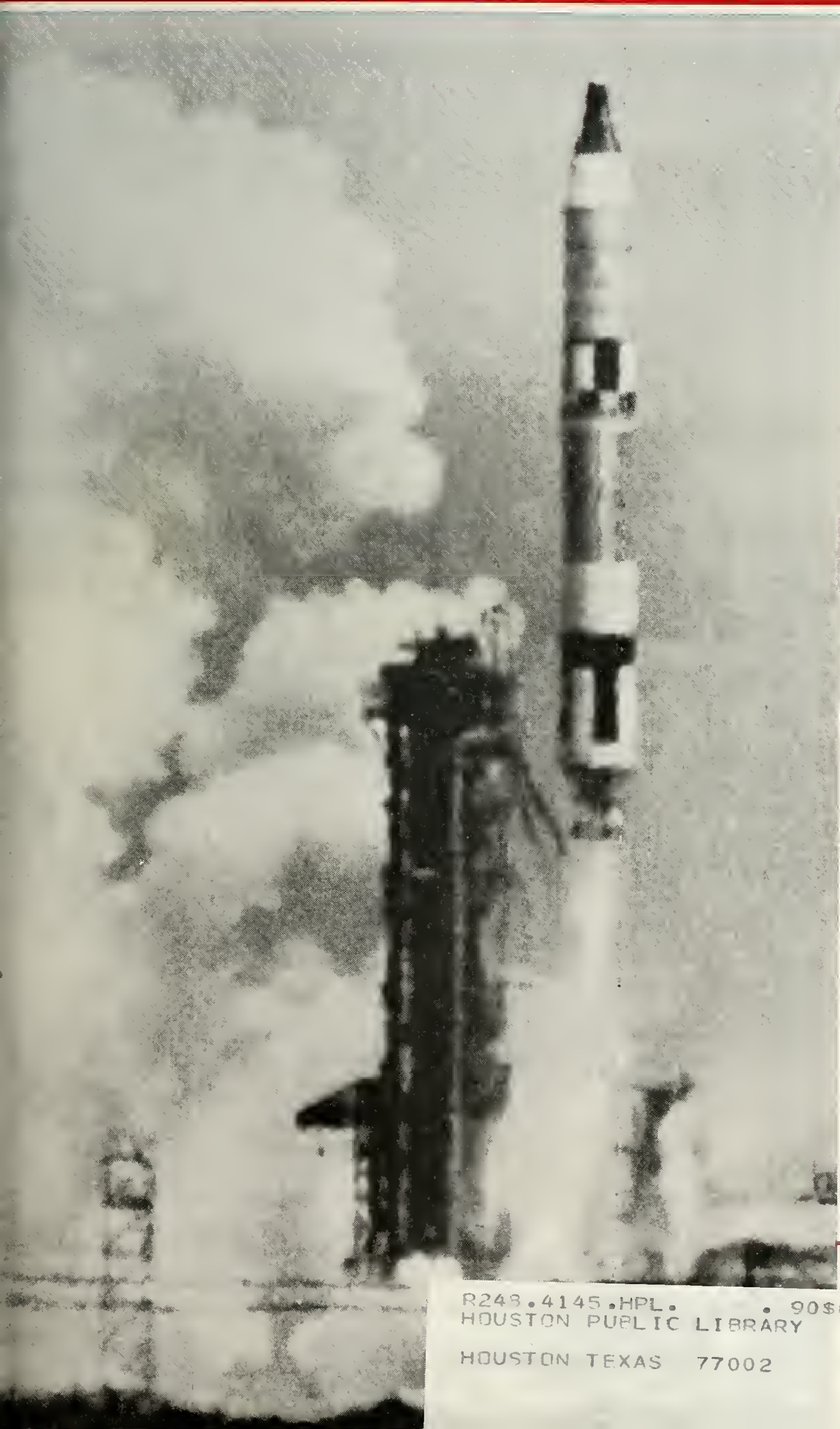

NASA Now Weighing Major Change In Apollo

Cause of Gemini 8 Abort Uncertain

MOL Support Role Urged for AAP

ARC Probes Space Vacuum Freezing

Flawless Start of Gemini 8

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RAYTHEON

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missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 18, Number 12 March 21, 1966

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THE COVER

Gemini 8 heads skyward from Cape Kennedy March 16, 101 minutes after its Agena target was fired into orbit. Early phases of flight went perfectly, including man's first docking with another object in space. Violent maneuvers after docking forced early termination (see p. 12).

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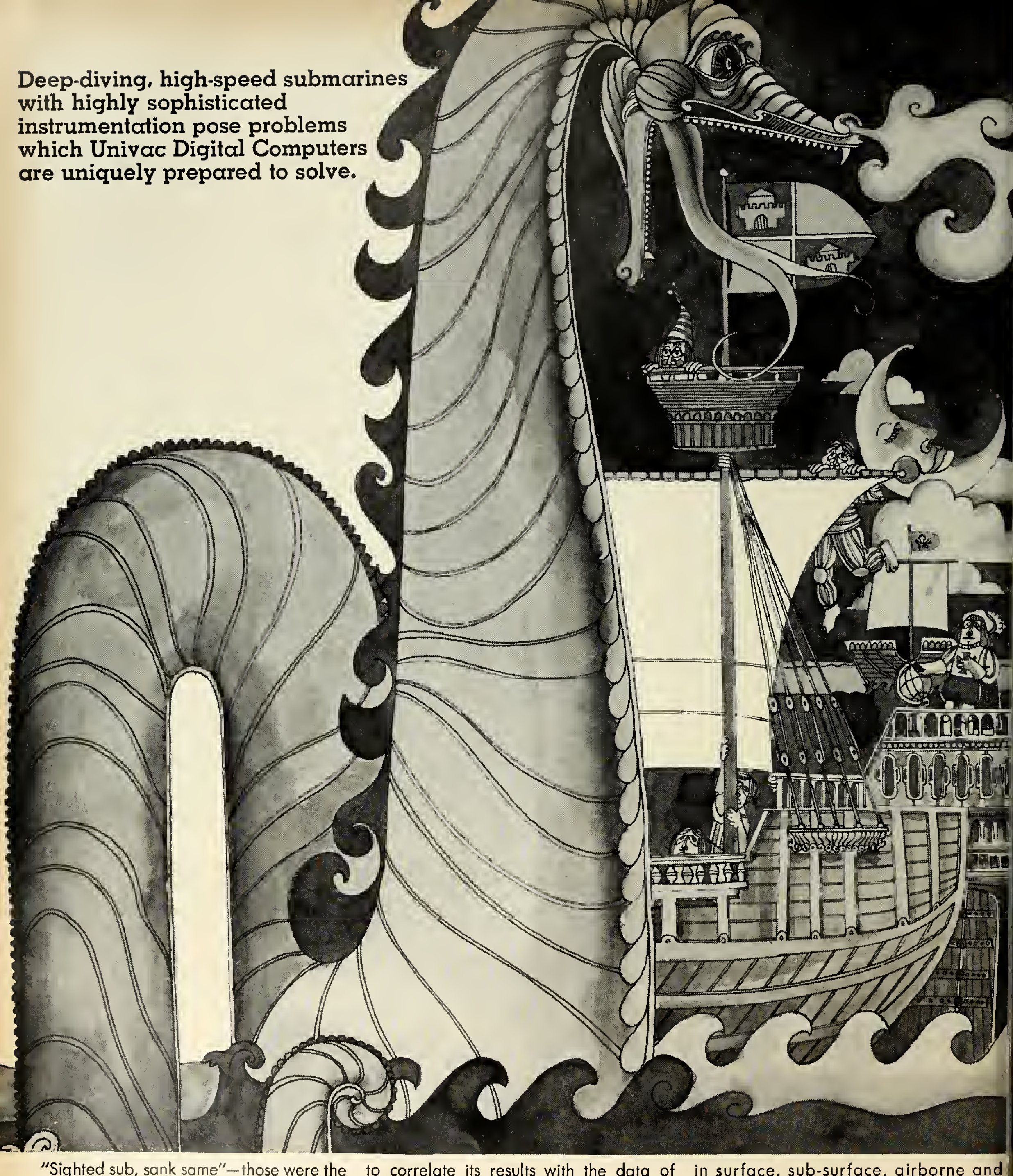
Deep-diving, high-speed submarines with highly sophisticated instrumentation pose problems which Univac Digital Computers are uniquely prepared to solve.



"Sighted sub, sank same"—those were the days.

Today subs are faster, run deeper and can stay under longer. Sub commanders are foxier. Evasion tactics are subtler. Even the water conspires against us. It's more crowded. (The fish, random currents, temperature and pressure pockets were always there—but now we pick them up.)

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letters

ITU Service in India

To the Editor:

The article "Comsat Use Should Swell Dramatically," M/R, Jan. 31, p. 34 contains a statement by President Johnson's Citizens Committee on Communications to the effect that there is no U.S. engineer in the ITU Technical Assistance Corps. During 1965, I served as an ITU Expert in Satellite Communications and Project Manager, in Ahmedabad, India.

During that seven-month period, I was chief advisor to the Indian government on the design and establishment of a Center for Research and Training on the Uses of Satellite Communications.

Philip A. Rubin
Space Systems Division
Aerospace Group
Hughes Aircraft Company
El Segundo, Calif.

AFCRL Dust Studies

To the Editor:

Regarding the $50,000 contract awarded to the National Research Corp. (M/R, Feb. 28, p. 11) to examine under extreme conditions materials of the type believed to exist on the surface of the Moon, you should know that the study *does not* mark "the first production of the dust under extreme vacuum condition."

Here at the Air Force Cambridge Research Laboratories we have conducted such studies for the past three years, and in fact operated three vacuum chambers designed specifically for these studies capable of operating under pressures as low as 10^{-11} torr.

La Verne E. Woods
Chief, Research Information Office
Air Force Cambridge Research Laboratories
Laurence G. Hanscom Field
Bedford, Mass.

Fairly Farflung

To the Editor:

Thanks for noting in your Feb. 28 "Names in the News" that Bill Rollnick has joined Data Technology Corporation as Vice-President for Finance and Administration. The item, however, has caused some confusion regarding his and my former associations with the vast Clan Fairchild.

Bill was not formerly Director of Marketing at Fairchild Instrumentation, as you reported. He was, before coming aboard at DTC, Assistant Secretary and Military Marketing Manager at Fairchild Hiller Corporation, a corporate entity in its own right and in no way connected with Fairchild Camera & Instrument Corp., except that Sherman Fairchild is a stockholder of substance in both.

Our PR release of Bill's appointment had also noted that I had recently joined DTC—from Fairchild Instrumentation, where *I* was Director of Marketing. Fairchild Instrumentation is a division of Fairchild Camera & Instrument Corp.

Perhaps we mentioned too many Fairchildren in the same story. I hope this will straighten things out and get Bill and me once more properly identified as to our Fairfathers.

Gordon L. Ness
Executive Vice-President
Data Technology Corp.
Palo Alto, Calif.

Fool Britannia?

To the Editor:

Your Feb. 28 leader ("None If By Sea") is an eloquent and very accurate assessment of the UK Government's incredible double blow at the nation's aircraft industry and the Royal Navy.

To many of us here, what makes it all particularly painful is the very real doubt that it was truly necessary. If Britain cannot buy as much as she would like from the home aircraft/missile manufacturers, she might at least buy a good deal more—thus perhaps keeping this once highly respected industry alive (together with a basis, at least, for development—even yet—of a healthy space establishment).

It is possible of course that some of the public's resentment of this action will be reflected in the General Election. Unfortunately, it will be difficult to ascertain, as leaders in both parties have identified themselves with the policy of progressive dismantling.

Even more uncalled for is what can only be regarded as the "phasing out" of the Navy. Surely Britain, even if she may no longer be first on the seas, still has the will and the resources to maintain an honourable and formidable role!

May we now look for the demolition of the Nelson column in Trafalgar Square?

F. Armstrong
London

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REPRINTS of the latest edition of the Missiles and Rockets *Astrolog, which appeared in the March 14 issue, may be obtained from:*

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SCIENCE/SCOPE

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Earth-Facing Satellites. A new breed of satellite equipped with weighted booms will constantly "look" earthward. Purpose of booms: to interact with the earth's gravitational field, keeping the satellite stable. Built by Hughes for NASA, the new ATS satellite family will conduct scientific studies in communications, weather, ion engines, solar radiation.

Wanted: Sharp Engineering Brains. In 1965, Hughes hired a record number of engineers to meet challenging demands in programs like BADGE, EARLY BIRD, PHOENIX and CORDS. Personnel people say 1966 will see even more engineers and scientists added to our West Coast laboratories and production plants. (For information on current openings, address D. A. Bowdoin, Hughes Aircraft Co., Culver City, California. An equal opportunity employer.)

Zero Defects Award to Hughes. In recognition of outstanding contributions to national defense through reduction in errors, Hughes recently won the coveted Air Force Zero Defects Achievement Award. Accomplishments like a 98% reduction in welding errors, an 85% improvement in accuracy of missile calibration, added up to a saving equivalent to 250,000 man hours in one year.

Planet Recognizer. A machine that would automatically categorize a planet's surface from a speeding space vehicle is being studied by Hughes Research Laboratories. Multivac Mark II, which recognizes patterns electronically, would "see" a planet via television and identify its surface by comparing it with a "landscape library".

New Technical Papers Offered. Recent available titles include: RR 341 "Linearization Based Upon Differential Approximation", RR 347 "Improvement of the Cluster Variation", "Electron and Ion Emission from Cesiated Refractory Compounds", "Voltage Dependence of the $Al-Al_2O_3$ Barrier Height". For reprints please write: Technical Information Dept., Hughes Research Labs, 3011 Malibu Canyon Road, Malibu, California.

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The Countdown

WASHINGTON

AF Seeks Comsat Antennas

Air Force FY '67 budget request includes funds for an expansion of effort in development of communication satellite antennas aboard aircraft. Goal is to provide direct access to satellites for voice and digital communications.

Soviets Still Ahead in Space Race

Although President Johnson is firm in his intention that the U.S. be first to the Moon, NASA officials are not that optimistic. NASA Administrator James Webb told Congress that the Soviets have widened the space gap in the past year. He said chances are growing that the Soviets will land a man on the Moon before the U.S. does.

Improvements Sought in Sparrow

Improvements needed in *Sparrow* missiles already in Fleet and Air Force service in Vietnam, as called out in the supplemental appropriations bill, include better performance in a very humid environment, additional structural mechanisms and more reliability.

McNamara Says MOL Can't Use the Money

Secretary of Defense Robert McNamara estimates that funds to be carried over from FY '66 to FY '67 for the Air Force's *Manned Orbiting Laboratory* total about $40 million. (An additional $159 million was requested in new FY '67 funding.) "This is not because of any desire to slow up the project," says the Secretary, "but rather because the research program can't properly use these funds in that time."

Lack of NASA Support Hit

Rep. Olin Teague (D-Tex.), chairman of the Manned Spaceflight and NASA Oversight subcommittees of the House Space Committee, is upset at the lack of support in the Executive branch for a more aggressive, far-sighted space program. He questions especially the wisdom of waiting another year to make major decisions on post-*Apollo* projects. Teague believes the nation's space capabilities already are eroding.

Maverick Development Confirmed

Air Force Deputy Chief of Staff Lt. Gen. James Ferguson has confirmed that the service will move the new *Maverick* (AGM-65A) air-to-surface missile system into development with FY '67 funds (M/R, Dec. 6, p. 14). The missile is based upon the *Walleye* TV-guidance seeker but will be smaller, will be propelled and will provide capability against smaller, harder targets.

SABRE Guidance System Going Well

Gen. Ferguson also told the House Armed Services Committee that SABRE (Self-Aligning Boost and Re-entry) guidance system development is progressing very well. He says new funds would be used for procurement and integration of system components. SABRE, a very rugged and highly accurate inertial system, is believed to be intimately tied to advanced U.S. ICBM planning for maneuverable re-entry. It probably is linked to the new *Minuteman III* program.

Air Force Installing 440L System

Air Force has completed part of the installation of its System 440L, the over-the-horizon radar project expected to substantially increase ICBM early warning times over the north polar regions. Existing BMEWS radars, limited by curvature of the Earth to line-of-sight ranges, can detect ICBM's only relatively late in the early flight stage, probably about at nose separation. OTH radars will enable launch-phase detection.

NASA Reduces Agena Costs

NASA has reduced slightly the cost of *Agena* launch vehicles by insisting that its center use more standardized components. Officials say they have been paying a large price for mission-peculiar modifications to the Lockheed *Agena*. Economies have been effected by use of already-developed shrouds and adapters to minimize the amount of special work by the manufacturer.

Gemini To Get Window Shields

Remaining *Gemini* spacecraft are to be equipped with glass window covers to protect against the unknown substance deposited on previous spacecraft during exit heating. The covers, which actually are used *Gemini* windows, will be removed mechanically from inside the spacecraft by each pilot loosening a knurled nut, pushing a rod through to jettison the cover and retightening the nut. Astronaut David Scott, during his stay outside *Gemini 8*, was to have wiped the windows clean with a special cloth which would then have been brought back for analysis. That activity, of course, was scrubbed on the aborted mission.

INDUSTRY

Hound Dog To Get New Guidance

Improvement in the terminal guidance system of the North American Aviation *Hound Dog* stand-off missile (M/R, Jan. 31, p. 16) will be accomplished by use of a new Terrain Contour Matching (TERCOM) technique for accurate navigation fixes. On-board computer functions and memory will be expanded to handle inputs from Earth relief intelligence plus those from the missile's radio altimeter and inertial guidance system. FY '67 funds will provide for flight test.

INTERNATIONAL

Britain Disenchanted with ELDO

Successful in obtaining an eight-week delay in the next meeting of the Committee of the European Launch Development Organization, the British will use the time to seek a compromise permitting them to reduce their commitment to ELDO. Asking for a review of ELDO's future, the British issued a hard-hitting statement considered a real slap at the organization: "Her Majesty's Government believe that the future of European technology will not be served by the pursuit of projects which are either economically or technically unsound. No practical partnership can be sustained on such a basis."

Japanese Postpone Lambda Launch

University of Tokyo's Institute of Space and Aeronautical Science has announced postponement of the scheduled March 26 launch of the *Lambda 4S* vehicle which might have orbited that nation's first spacecraft (M/R, Feb. 7, p. 7). The Institute said defects found in the third stage of the *Lambda* vehicle caused the postponement.

The Missile/Space Week

Soviet Manned Flight Readied

Reports from Moscow indicate that preparations are under way for a new Soviet manned spaceflight, possibly carrying two men into a high Earth orbit of about 550 mi.

The news coincided with the return of the two Russian space dogs on March 16, following a 22-day flight. A Tass announcement said that although the state of the animals was "good" after landing, both dogs suffered pronounced irregularities in heart beat during the flight.

Reports on the manned flight differ on whether the crew will attempt to rendezvous with, and transfer to, another unmanned satellite. While this opinion was expressed by the Moscow correspondent for a Belgrade news service, other sources indicated that only one ship would be launched at this time.

Probable date, from all accounts, is that the shot will be attempted sometime before the twenty-third Soviet Communist Party Congress, which opens in Moscow at the end of March. The Yugoslav report also indicated that the next step would be the assembly of a space platform, possibly by a crew of five to eight.

In the meantime, photos and schematics of the dog-bearing biological laboratory were released to MISSILES AND ROCKETS by Novosti Press Agency.

The experiment, which was assembled by V. N. Pravetsky and B. B. Yegorov along with the late N. M. Sisakyan, was aimed mostly at assessing the response of the animals' cardiovascular systems to spaceflight.

Arterial pressure was measured through a probe grafted into the animals' arteries. The same probe, the Novosti article said, was used for introducing pharamacological agents, helping to assess the functional state of the reflex regulation of the circulatory mechanisms.

Other measurements included registration of the action potentials of the heart with grafted electrodes, the pulsation curve of the carotid deviated into a skin pocket, mechanical work of the heart through seismocardiograph, and respiration.

In addition, electrodes were grafted into the peripheral nerves (sinus nerve) to assess the work of the brain in regulating vascular tonic state.

The capsule also included a number of radiation dosimeters and biological experiments to assess the radiation hazard at the 550-mi. altitude in which the ship travels. (M/R, March 14, p. 44).

Navy Seeks Improved Homing

The Navy is pressing an extensive evaluation to quickly provide better radar-homing missile capability for U.S. aircraft in Vietnam.

Poor performance thus far of the Navy's first-generation *Shrike* anti-radiation missile (M/R, Oct. 18, p. 18) against enemy radars operating at North Vietnamese missile sites has spurred the investigation.

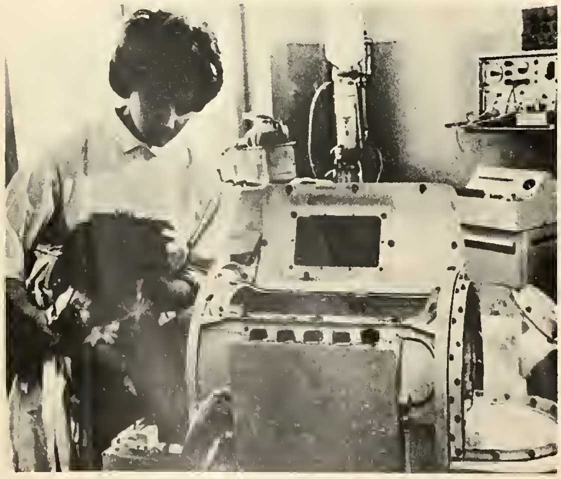
Both the Navy/Maxson *Bullpup* air-to-surface missile and the Air Force/Hughes *AIM-47A* air-to-air missile are being considered for this new role, equipped with an improved version of the *Shrike* guidance seeker. An improved version of *Shrike* is also in the competition.

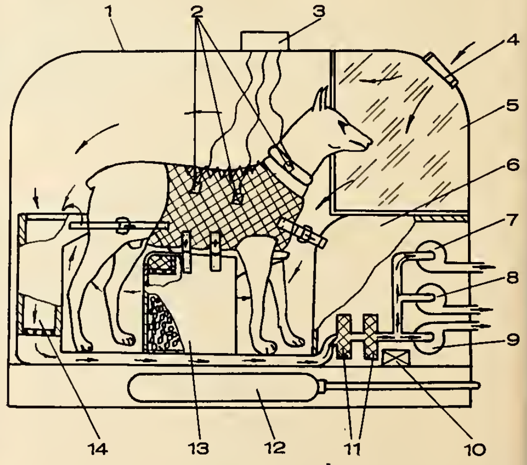
A decision is expected within the next several weeks.

Sources close to the program say a continued buy of *Shrike* in an improved configuration is expected, but it is also likely that one or both of the other missiles may be put to use as a radar-homing weapon to improve capabilities against certain types of targets. Both weapons reportedly offer other advantages over *Shrike*—either in autopilot performance, fuzing, or propulsion capability.

The *AIM-47A*, formerly *GAR-9*, is the armament portion of the Air Force's YF-12A advanced interceptor aircraft program now being evaluated. Missile firings thus far have been successful, according to AF reports.

LEFT: One of the two space-traveling Soviet dogs is shown being placed in Cosmos 110 container through upper and rear hatches. RIGHT: Diagram of the Cosmos cabin: 1) Airtight container of animal (made of aluminum alloy). 2) Physiological pickups. 3) Physiological pickup unit. 4) Air intake. 5) Transparent canopy. 6) Ventilators, filters and other units and instruments of life-support system. 7) Ventilator. 8) Duplicating ventilator. 9) Powerful additional ventilator. 10) Special electronic device switching in duplicating ventilator. 11) Air-cleaning filter. 12) Pneumatic system with compressed-gas cylinder. 13) Liquid waste collector. 14) Solid waste collector. (Pictures from Novosti Press Agency.)





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House Passes DOD Request

The FY 1966 defense supplemental appropriations bill was passed by the House of Representatives by a vote of 389 to 3 on March 15. The vote followed several hours of debate in which Republican members of the Defense Appropriations Subcommittee criticized the Administration for neglecting the total defense picture and censoring the testimony of defense witnesses before the Congress.

In a speech on the House floor, Rep. Glenard Lipscomb (R-Calif.) charged that some research and development programs are "being funded at a level of effort lower than a realistic assessment of the overall threat would indicate they should be."

While it has been repeatedly stated that DOD planning has been aimed at enabling us to pursue the type of conflict as is going on in Vietnam, Lipscomb said, "it took an escalated activity in Vietnam to produce a fund request to support a level of effort needed to make these new findings and weapons available quickly."

Lipscomb also joined other minority members of the subcommittee, Melvin Laird (R-Wis.) and William E. Minshall (R-Ohio) in filing separate views charging that witnesses before the committee have been directed to withhold their own views from the committee unless pressed, and if pressed, to argue against their own position if it is contrary to established Defense Dept. policy.

Minshall also told the House that "the abuse of the 'top secret' stamp to blank out politically sensitive portions of their testimony before the subcommittee is ever more in evidence."

The bill grants the full amount requested by DOD of $12,345,719,000.

OAO Launch Rescheduled

Launch of the first *Orbiting Astronomical Observatory*, scheduled for March 24, has slipped to March 28.

NASA announced that experimenters wanted more time to check out the experiments.

Shots of the Week

Gemini-Titan 8, carrying Command Pilot Neil Armstrong and Pilot David Scott, was placed in orbit March 16, following the launch of the *Agena* target booster 101 minutes earlier (see p. 12).

- The Soviet Union launched the *Cosmos 112* scientific satellite on March 17. The spacecraft was placed in a 90-minute orbit with an apogee of 350 mi. and a perigee of 132 mi.
- The Air Force successfully fired a two-stage *Nike-Iroquois* sounding rocket from Santa Rosa Island Aerospace Launching Complex on March 9.

SNAP-10 Completes Schedule

The ground version of the SNAP-10A nuclear reactor was shut down on schedule Mar. 16 after 10,000 hrs. of operation, the longest continuous run of a nuclear power plant.

The power generator was first started up at North American Aviation's Atomic International Div. on Jan. 22, 1965. It will now be taken apart for examination.

Correction

Under the Navy reorganization plan, the Bureau of Naval Personnel and Bureau of Medicine and Surgery will report directly to Chief of Naval Operations, not to the Secretary of Navy, as reported in M/R, March 14, p. 16.

NERVA Firing Successful

The breadboard NERVA nuclear rocket engine successfully passed its seventh test March 16. The run was for 18 minutes, for 13 of which the system ran at its full power of 1,100 mw, generating 55,000 lbs. of thrust.

Although the originally scheduled series of firings in the NASA/Atomic Energy Commission program were completed after the sixth test on March 3, scientists felt the system could withstand further exercising before being dismantled and examined. Last of the firings is scheduled for later this month.

New Circuit Subsystems Shown

NEW YORK—A new series of microminiaturized multi-functional integrated-circuit subsystems, containing the equivalent of up to 116 discrete components, was unveiled here last week by Sylvania Electric Products, Inc.

Fabricated on single, one-layer, silicon chips averaging 46 x 80 mils in area, the extremely complex digital-circuit elements will be marketed initially for use in computer and digital-communication systems.

Contained in conventional Sylvania 14-lead, dual, in-line plug-in packages and TO-85 flat packs, three types are now available; fast-adder arrays, a four-bit binary register, and a decade frequency divider.

The new units, called monolithic digital functional arrays, are considered the first of a family of soon-to-be larger arrays. Future subsystems, according to Sylvania's Alvin B. Phillips, general manager of the integrated circuits division, will include large-scale shift registers, decade counters, encoders and decoders, and memory arrays, built-up in a single package by stacking and interconnecting the new smaller chip arrays.

Believed to be a first of the kind, the type SM-50 decade frequency divider contains 40 IC gates created with the equivalent of 116 transistors, resistors and diodes. The units may be employed to process both analog and digital input signals, producing a square-wave output that is precisely 0.1 the input signal frequency. Inputs can be handled from 5 cps to 30 mc. SM-50 is a six-stage circuit wherein the first shapes the input signal, three stages then perform synchronous division-by-five, the next provides a divide-by-two function and completes the dividing process, and the sixth serves as a buffer stage providing an a-c and d-c fan out of from 6 to 15. Power consumption is 150 mw with ±1v noise margin.

The new fast-adder arrays, designed to perform digital computer arithmetic and logical functions including anticipated carry, contain the equivalent of 73 transistors, resistors, and diodes. Initially, the series will appear in three forms: SM-30, single-stage independent fast adder; SM-20, single-stage dependent fast adder; and SM-10, single-stage full adder. Parallel anticipated-carry fast adders larger than four-bits can be built up from the adder arrays plus the addition of a specially designed carry decoder unit, the SM-40. Power dissipation of series units is 120 mw with a ±1.0v noise margin.

Bendix Wins ALSEP Award

The space agency is negotiating a contract with Bendix Corp. to provide four *Apollo* Lunar Surface Experiments Packages (ALSEP).

The cost-plus-incentive-fee award is expected to total approximately $17 million. Bendix was one of three firms which did initial design studies on ALSEP under six-month, $500,000 contracts.

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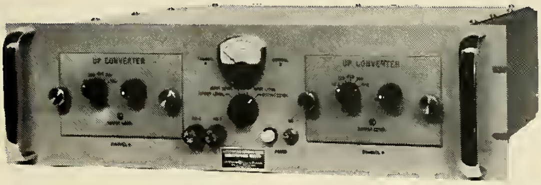

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Apollo Plans Change; Gemini 8 Probed

Switch in early flight schedule could push first manned Apollo flight into 1967; officials seek answer to malfunction following docking

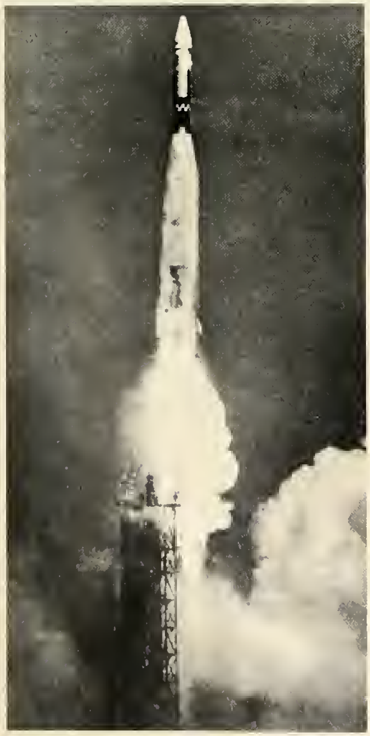
NASA OFFICIALS have decided on a major change in the Project *Apollo* launch schedule, even as they continue to study the aborted but still spectacular *Gemini 8* mission.

Late last week, experts at the Kennedy Space Center and Manned Spacecraft Center still had not pinpointed the malfunction that forced the *Gemini 8* spacecraft—which achieved the first space docking when it linked up with the *Agena* target vehicle on March 16—to return to Earth after less than one day in orbit.

They believed the violent combination yaw and roll may have resulted from a mechanical breakdown unique to the *Gemini 8*. Hence, they hoped it might not delay the four remaining *Gemini* flights. It may be necessary to juggle some mission experiments to cover the sophisticated extravehicular operations and docking experiments not accomplished by *Gemini 8*.

This assessment was indefinite, the officials said, because a final determination of the cause of the problem, and scheduling of future missions, could not be carried out until data were studied in more detail and technicians had a chance to inspect the spacecraft.

Perfect launch of Agena precedes Gemini.



Apollo switch—While evaluation of the curtailed *Gemini* shot proceeded, it was learned that officials have elected to approve a change in the *Apollo* three-man spacecraft schedule which could delay the first manned flight in the program.

The change was not connected with the *Gemini* mishap, but reportedly will be caused by late shipment of the *Apollo 202* spacecraft to Cape Kennedy.

The new plan calls for delaying until August the second *(202)* launch of the spacecraft, now scheduled for late June/July. In its place, the space agency will move up the *Apollo/Saturn IB 203* flight to July.

The *203* mission does not call for the use of a flight-rated spacecraft and will simply be a test of the launch vehicle's S-IVB second stage restart capability and the effect of weightlessness on its liquid hydrogen fuel.

The *Apollo 202* test, however, will be the second unmanned test of a flight spacecraft: its success or lack of success will have a sharp effect on the first manned orbital flight scheduled for late this year. If some technical problems develop during the *202* flight, there will be at least 30 days less to find a fix before committing the spacecraft to a manned shot. This could push the manned flight into next year.

Trouble develops—In addition to the first docking of two vehicles in Earth orbit, the March 16 flight marked the first time the U.S. has performed a simultaneous countdown of two launch vehicles.

Moving at a velocity of 1 fps, *Gemini 8* hooked up with *Agena* at 6:15 p.m. EST, following a 6-hr., 34-min. chase through space. The elation at Mission Control Center changed to gloom and then fear for the astronauts' lives, however, when Command Pilot Neil Armstrong reported that the docked spacecraft/target vehicle had begun to yaw and roll.

He immediately moved the *Gemini* away from the *Agena,* but then reported that the spacecraft was rolling even more violently. Finding his Orbital Attitude Maneuvering System (OAMS) apparently inoperative, Armstrong fired all 16 of the 25-lb.-thrust Re-entry Control System rocket thrustors to stabilize the spacecraft. The system is usually used to maintain correct pitch, yaw and roll when astronauts decide to make a controlled rather than a ballistic re-entry. With the OAMS and RCS systems both out, Mission Control decided to terminate the mission immediately because only one system—the retro-rockets—remained to bring the astronauts back to Earth.

The four retro-rockets all fired on schedule during the seventh revolution of the Earth, and the spacecraft splashed down in the Pacific Ocean some 500 mi. southeast of Okinawa. Sighted even before landing by an Air Force rescue plane, the *Gemini* impacted at 10:23 p.m. EST. Slightly more than three hours later—at 1:28 a.m. EST on March 17—the astronauts were picked up by the destroyer USS Mason and taken to Okinawa. They were later flown to Cape Kennedy for normal debriefing.

The spacecraft was recovered several minutes after the astronauts. The flight—scheduled to orbit the Earth for 71 hrs.—had lasted exactly 13 hrs., 47 min.

Belief that the yaw and roll problem may be unique to *Gemini 8* is based on the fact that the spacecraft continued to roll strongly after the de-docking, while the *Agena* remained stabilized. Also, when officials later fired the *Agena* propulsion system to put the vehicle into a circularized orbit of 220 n. mi.—for a future rendezvous attempt by the *Gemini 10* spacecraft—the *Agena* functioned perfectly.

The delay in more sophisticated extravehicular operations may be forced because Pilot David Scott was unable to make his 2-hr., 40-min. walk at the end of an 80-ft. tether. Officials do not want to use the astronaut maneuvering unit (AMU) until data are obtained on the whiplash effect of such a long tether. Another major objective

This report was prepared by NASA Editor Hal Taylor, at Cape Kennedy, and Contributing Editor Jinx Mercer, at Mission Control Center, Houston.

of the *Gemini* program—firing of the *Agena* propulsion system during docking—probably will have to be deferred because the malfunction prevented several tests of spacecraft/target vehicle structural integration.

Perfect start—The March 16 lift-offs of the *Agena* and the *Gemini 8* spacecraft were both on the planned time. Both launch vehicles performed flawlessly.

The launches followed a one-day delay from the planned March 15 lift-off caused by leaks in both the *Agena's Atlas* launch vehicle and the environmental control system (ECS) of the *Gemini* spacecraft.

The *Atlas* problem was found to be a level sensor which was falsely indicating a leak. This was fixed by putting a smaller amount of propellant in the tanks. The ECS problem was solved by taking the ECS system from the *Gemini 9* spacecraft and replacing it in *Gemini 8*.

The *Agena* was blasted aloft at exactly 10:00 a.m. EST after a perfect countdown by the General Dynamics/-Convair-built *Atlas* booster.

At 2 minutes and 11 seconds into the flight, the booster shut down exactly as programmed. Sustainer engine shutdown followed at 4 minutes and 40 seconds.

Separation of the *Agena* was clocked at 5 minutes and 35 seconds and the *Agena* reached orbital altitude at 9 minutes and 40 seconds.

The sharp performance of the *Atlas* and the Lockheed-developed *Agena* placed the target vehicle in the planned 161-n.mi.-high orbit. Its exact orbit was a circular 160.6 n.mi. high.

Even as the *Agena* moved toward its first orbit of the Earth, the perfect countdown on the Martin Co. *Titan II* booster continued, also with no technical holds.

At 11:40:59, the 430,000-lb.-thrust booster blasted the 7,000-lb. McDonnell Aircraft *Gemini* capsule aloft right on the planned schedule. Both launch vehicle and spacecraft systems worked nominally as the *Gemini 8* was inserted into orbit with a perigee of 86.2 n.mi. and an apogee of 146.2 n.mi. This was almost right on the planned orbit of 86.8 mi. perigee and 146 mi. apogee.

At the time of orbital insertion, *Gemini 8* was 1,050 mi. behind its *Agena* target.

Catching up—Command Pilot Armstrong began the first of a series of catch-up maneuvers at 1:34:37 into the flight when he fired the Orbital Attitude Maneuvering System in a height adjustment maneuver at a velocity of 92.9 fps. When it was completed, *Gemini 8* trailed the *Agena* by only 719 n.mi.

The second maneuver occurred at 2:18:25 into the flight, when the OAMS was fired for 8 seconds to achieve a posigrade thrust of 50.6 fps to change the orbital period. After 2:45:31 of flight, with the blunt end of the spacecraft forward, the thrustors were fired again in a posigrade direction at a velocity of 25.7 fps. As the spacecraft neared its third apogee, Armstrong circularized the orbit to 147 n.mi. This was achieved by a posigrade firing of 61.6 fps shortly before the crew reported that the on-board radar was locked on the target vehicle.

The crew then switched the computer to the rendezvous mode and began terminal-phase systems checkout and procedures. At 5:11 minutes, about one minute after entering darkness, the OAMS system was fired at a velocity of 33 fps and terminal phase began.

Gemini 8 then pitched up 27 degrees in preparation for a posigrade maneuver with the aft thrustors, which were fired with a velocity of 43.6 fps. At the beginning of the firing, the spacecraft was only 4 mi. from its target.

At 5 hrs., 44 min., the range had dropped to only 14,000 ft. At 5 hrs., 48 min., it was only 5,700 ft.

Armstrong, after 5 hrs., 58 min., reported that the two vehicles were only 150 ft. apart and that he was station-keeping with the target. He said the *Agena* after almost 8 hours of orbital flight looked fine and that its antennas were all in proper position.

Approximately 30 minutes later, the historic achievement of the first docking of two vehicles in Earth orbit was chalked up.

Speculation—After review of all air-to-ground transmissions with the crew and flight controllers, NASA officials were still in a quandary as to the source of the sequence of events which set the *Gemini 8* and *Agena* tumbling "violently"—or when it actually occurred.

Mission Director William C. Schneider indicated that they would not speculate until all the spacecraft data and tapes were analyzed and until they could go through data received at remote sites which could take as long as a week.

Some speculation did arise, however, that a wrong command was received by the target vehicle. Instead of turning on the *Agena* tape recorder, a command to yaw was received. It is also possible, Schneider said, that a "short" in the *Agena* or the spacecraft while the two were in combination could have triggered the unpredicted events.

According to a NASA transcript, Armstrong turned on a spacecraft attitude-control thrustor to gain control of the violent yaw-roll condition while they were docked with the *Agena*. Using OAMS thrustors, they reduced the tumble rate to a point where they could safely undock and "maneuvered away from the *Agena* at several feet per second." The spacecraft rate became excessive and they started "winding up," Armstrong said, so he activated both rings of the re-entry control system for additional control authority. He reasoned that a thrustor had become stuck in the open position. After they gained control, Armstrong noted that *Agena* attitude control thrustors where still firing even after he had commanded them to turn off. ■

Ambitious Plans Weighed for Geminis

SPACE AGENCY officials are considering several dramatic exercises for later flights in the *Gemini* program.

The unprecedented linkup of *Gemini 8* and its *Agena* target vehicle could easily be overshadowed if some of the proposed flight plans for *Gemini 9* through *12* are approved.

Among the ambitious plans being urged by quarters within NASA and industry are a space-rescue simulation mission in which the *Gemini* would rendezvous with an orbiting *Apollo* Command Module, orbiting refueling practice by transferring propellant to the *Gemini* from an orbiting *Saturn* S-IVB stage, and increasing the size of the *Gemini* heat shield so that two astronauts can take their spacecraft far out into space for the recovery of meteoroid panels from an orbiting *Pegasus* satellite.

Another proposal calls for making rendezvous more difficult by launching the *Agena* at a time when the orbiting *Gemini* crew is not aware of it.

Before the aborted *Gemini 8* flight, NASA officials confirmed that some of these proposals were under consideration. But they said no final decisions on future missions have been made apart from their duration and the rendezvous method to be employed.

The only thing final at this point, one spokesman said, is that each remaining mission will last three days and that *Gemini 9* rendezvous will be attempted on the third orbit, *Gemini 10* on the fourth, and *Gemini 11* and *12* on the first.

House Committee Urges AAP Merger into MOL Program

by Heather M. David

THE HOUSE GOVERNMENT Operations Committee has recommended that NASA participate in the Air Force's *Manned Orbiting Laboratory* program rather than embark upon a separate *Apollo* Applications Program of its own.

A report prepared by the Subcommittee on Military Operations, which investigated missile and space ground-support operations, and adopted by the full committee, urged priority for the military needs of the *MOL*—with satisfaction of the objectives of the AAP handled as a sideline of *MOL*.

The report stated that while AAP is not yet an approved program, both Air Force and NASA are nearing a point-of-no-return where "separate and largely duplicating" programs cannot be avoided.

"Inasmuch as both programs are still research and development programs without definitive operational missions, there is reason to expect that with earnest effort both agencies could get together on a joint program incorporating both unique and similar experiments of each agency," the committee stated.

It also noted that such a plan would give each agency the necessary experience and information to plan larger space stations, for which NASA at least has stated a potential future need.

The committee, which last year made a widely circulated recommendation for immediate action on the *MOL*, said that a merger between *MOL* and AAP should be "effected within the existing scale of priorities which accords to the military experiments greater urgency."

MOL ground support—The Dept. of Defense was urged to make maximum use of existing DOD and NASA facilities for the *MOL* rather than build new ones.

However, while DOD has said that no new development support resources on the scale of NASA facilities will be necessary because Douglas Aircraft Co., *MOL* prime contractor, has extensive new facilities, the committee questioned whether Douglas facilities can handle all phases of *MOL* development support.

One of the items it questioned was whether Douglas's vacuum chambers and simulators were large enough to accommodate the projected size of the *MOL* spacecraft. The group recommended use of existing simulation and test facilities, such as those at NASA's Manned Spacecraft Center and the Air Force's Arnold Engineering Development Center, should this be necessary.

Tracking systems—NASA and DOD passed up "big savings" by going to different tracking systems, the committee said, since about $25 million will be spent by NASA for the Unified S-Band system, and $32 million by DOD for the Space-to-Ground Link Subsystem (SGLS).

The group urged a vigorous effort towards standardization of existing or future instrumentation equipment, but acknowledged that the time is now past when a choice could be made between one or the other system.

It may be possible to use the USB equipment on the converted instrument ships for the ascent stage of *MOL*, and this could obviate additional investments in instrumentation ships, the report noted. However, the equipment does not have the degree of compatibility permitting its use for all on-orbit *MOL* support if that could not be met by current SCF stations, which will be equipped with SGLS equipment.

It will nevertheless take a concentrated effort to avoid expansion of the instrumentation fleet, the committee observed. The problem both agencies face is the conflict between two high-priority programs, involving the need to make compatible the deployment and scheduling of the ships for both *MOL* and the *Apollo* lunar-landing mission, with launches from different coasts.

The committee also suggested that DOD should make a decision as to whether the ship pool should be manned under the Navy Military Sea Transportation Service (MSTS).

The Satellite Control Facility and the Air Force National Range Division should be linked more closely in the interest of achieving a global network, the report added.

Single management of instrumentation facilities was urged where possible, as were steps to halt the proliferation of stations by different networks and agencies in adjacent areas around the world.

Apollo communications—The committee saw a strong need for reappraisal in the management of negotiations for communications services, such as those recently carried out between NASA and the Communications Satellite Corp.

It pointed out that NASA will lay out about $150 million or more for *Apollo* communications over a three-year period, including the underwriting of most of the costs for a new satellite communications system to be built by Comsat, modifications of ship terminals and conventional backup communications.

Some $27.79 million of this is involved in the Comsat contract, but does not include charges to be paid for the use of the foreign ground stations, which are expected to raise the total price for the Government to about $40 million for three years.

DOD also may make use of this system, and discussions are under way between DOD and Comsat over use of the channels to be available from the satellite, which will be stationed over the Pacific Ocean, the committee revealed.

It is possible, therefore, that the Government will be providing 75% of Comsat's annual revenues for some period of time, a portion of which will accrue to the international consortium in accordance with the ownership shares of the participating nations.

The committee indicated that a review of all the negotiations which took place between NASA, Comsat and DOD turned up some apparent reservations about the agreement among officials who approved it.

To this end, the group reiterated its recommendation made a year ago that the Directorate of Telecommunications be reorganized to give it power to adjudicate and make policy on such matters, assume the responsibility of the Secretary of Defense for identifying and evaluating Government user requirements for communications, and undertake systematic planning so that these requirements can be met in an orderly and economical way.

While "notable" progress has been made generally in achieving coordination among the agencies in ground-support activities, the committee said it observed "disturbing trends" which could defeat the progress made to date, especially in the creation of more complex and specialized equipment and facilities, which the agencies "show no great willingness to resist."

It urged strengthening of existing coordination mechanisms such as the Aeronautics and Astronautics Coordinating Board and its Space Flight Ground Environment Panel, active participation by the National Aeronautics and Space Council, and greater reliance on—and official recognition of—the Range Commanders Council and its sub-groups. ■

Increase in Voyager Funds Proposed

House space science subcommittee recommendations also to include landing probe for '69 Mariner Mars mission, $7.5-million increase for 260-in. solid rocket

A SUBCOMMITTEE of the House Space Committee will recommend to the full committee this week that $42 million be reprogrammed within NASA's Office of Space Sciences and Applications for *Voyager*-related programs.

Ancillary to this recommendation is the proposal to cancel the space agency plan to launch a *Mariner* spacecraft to the planet Venus in the 1967 opportunity—a move which would yield $18 million for the Mars efforts.

The recommendations of the Subcommittee on Space Sciences and Applications are part of a total sum of less than $5 billion, which will be voted on by the House Space Committee this week. Actions of the three subcommittees—Space Sciences and Applications, Advanced Research and Technology and Manned Spaceflight—resulted in no reductions to the research and development portions of the budget request.

Landing probe—Rep. Joseph E. Karth (D-Minn.), chairman of the SSA Subcommittee, told MISSILES AND ROCKETS that the group felt that since Mars has generally been designated the planet with the most scientific interest, emphasis should be placed upon it and a well-planned spending curve should be developed.

To this end, he indicated, the subcommittee voted "to rearrange NASA's priorities a bit," recommending that $20 million be spent to include a landing probe on the 1969 Mars *Mariner* shot to get accurate information on pressure, density and atmospheric structure in preparation for *Voyager*.

Officials from NASA's Ames Research Center and Jet Propulsion Laboratory were called by the subcommittee during the hearings to explain why they felt such a probe should be launched (M/R, March 7, p. 13).

An additional $22 million, Karth said, would go to initial laboratory work for areas which are potential bottlenecks for the *Voyager* program.

Venus shot out—Karth said that the action in recommending postponement of the Venus shot was based upon the fact that NASA has no other plans for following up such a shot for at least 10 years. Thus, any information gained would go unused.

Since the Venus *Mariner* spacecraft is already in mothballs, having been a backup spacecraft for a previous *Mariner* shot, it could be brought out at a later date, such as during the 1969 opportunity.

Recommendations of the subcommittee were to reprogram funds from a number of OSSA programs, including $1.5 million from the *Orbiting Astronomical Observatory* (*OAO*), which is the total amount requested for the fifth *OAO*.

Another program recommended at a lower level was launch vehicle procurement, cut $10 million. NASA has overestimated its requirements in the past and the subcommittee feels that it probably has done so in this year.

Supporting research and technology was earmarked to yield $5 million for *Voyager*, with the stipulation that none of that would come from lunar and planetary programs. Another $4 million is to come from launch vehicle procurement, and $3.5 million from administrative operations.

Big solids funded—Rep. Ken Hechler (D-W.Va.) announced that his advanced research and technology subcommittee has also done some rearranging, leaving the budget request at its level of $770,853,000 for the Offices of Advanced Research and Technology, Tracking and Data Acquisition, and Technology Utilization.

However, the subcommittee has voted to increase the 260-in. big solid funding by $7.5 million, which added to NASA's request of several million will enable the agency to conduct a full-length, 7-million-pound thrust firing by June, 1967. In addition, Hechler said, it will allow the design of a new nozzle and development of a method for thrust termination control.

While NASA Deputy Associate Administrator George Mueller told the committee that he saw no need for initiation of development of another launch vehicle for foreseeable manned spaceflight missions, the full committee was generally expected to go along with the subcommittee move.

Karth expressed his opinion that even if this were the case, the 260-in. solid should be pursued with an effort to replace one of the basic liquid-fueled boosters to get a comparison for future rocket development.

Another addition made by the subcommittee is $2.4 million for the SNAP-8 nuclear reactor, which will "give insurance in the development of the nuclear electric generator."

Aeronautics was another category recommended for increased funding by the subcommittee. An extra $2 million was voted to place additional emphasis on aircraft noise control, development of vertical and short take-off and landing planes, and additional support for supersonic transport aircraft.

Another $200,000 was added to the $4.8-million request for technology utilization "to enable private enterprise to take advantage of some of the newer developments in space technology."

The subcommittee cut $13.9 million from the tracking network, leaving a total of $265,335,000. This amount is $34 million more than is being spent in the current fiscal year.

A 5% cut was made in the administrative operations of the OART request, as well as $5 million from a $10-million fund for construction at the Electronics Research Center.

Manned Spaceflight—The full amount of $3,022,800,000 for research and development for *Gemini, Apollo* and Advanced Missions was granted by the manned spaceflight subcommittee, chaired by Rep. Olin Teague (D-Texas).

However, the group voted to defer action on a $9.1-million construction request for a lunar sampling laboratory planned by NASA for the Manned Spacecraft Center. While the group appeared to endorse the idea of the laboratory, it cautioned NASA that it should try to spread such construction of facilities to areas in the country that are lacking.

The construction fund was reduced by $581,000, for a proposed addition to the hazardous operations building at Marshall Space Flight Center. Administrative operations for manned spaceflight were also reduced, by $6.7 million, bringing the total reduction by the subcommittee to $16.4 million.

NASA officials are expected to have an opportunity to reclaim subcommittee actions before the full committee next week.

Voting on the bill is expected by the House before Easter. The Senate Space Committee also is understood to be near voting on the authorization measure. ■

Apollo Telescope Mount RFP Due Soon

$80-million program will be awarded to single firm for definition and hardware development; first ATM could fly in 1968 as AAP mission

PROPOSALS ARE EXPECTED to be requested from industry about April 1 on the space agency's new $80-million *Apollo* Telescope Mount (ATM) program.

The RFP will call for a six-to-nine-month systems definition phase. After bids are received and evaluated, one firm will be selected for the work. The same firm will later handle the hardware development phase.

ATM will be under the technical and managerial direction of Goddard Space Flight Center through the completion of its development. However, when it is ready to be flown, as part of the *Apollo* Applications Program (AAP), either the Manned Spacecraft Center or Marshall Space Flight Center will be responsible for its integration into the spacecraft. Because MSC has already been named to direct the integration of experiments into the AAP Command and Service Modules, it is likely to get the job of integrating ATM.

Deputy NASA Administrator Robert C. Seamans was briefed on the new program March 11. His final go-ahead for the program approval documents was expected late last week, according to informed sources.

The estimated $80-million cost of the program will cover three flight units and one prototype model.

Two years away—The ATM could fly as early as 1968, when AAP flights are expected to begin using launch vehicles and spacecraft left over from the *Apollo* lunar-landing program.

The relatively high cost of the program is caused by the intricate and exact stabilization that will be required to provide the pointing accuracy needed by an orbiting telescope. In addition to the automatic stabilization qualities, it will also have to have a manual override system which will permit astronauts to take over positioning of the telescope when required.

In discussing the program recently before the House Space Sciences Subcommittee, Edgar Cortright, deputy associate administrator for the Office of Space Sciences and Applications, said that even though the program had not (at that time) been approved, "it is a good time to decide how to handle it."

Cheaper than AOSO—NASA is requesting $3.7 million for ATM in its Fiscal 1967 budget and is expected to use another $3.7 million recovered from the canceled *Advanced Orbiting Solar Observatory (AOSO)* program to fund the project.

As far as the high cost is concerned, Cortright compared the $80-million figure to the estimated $142 million for four *AOSO* flight vehicles.

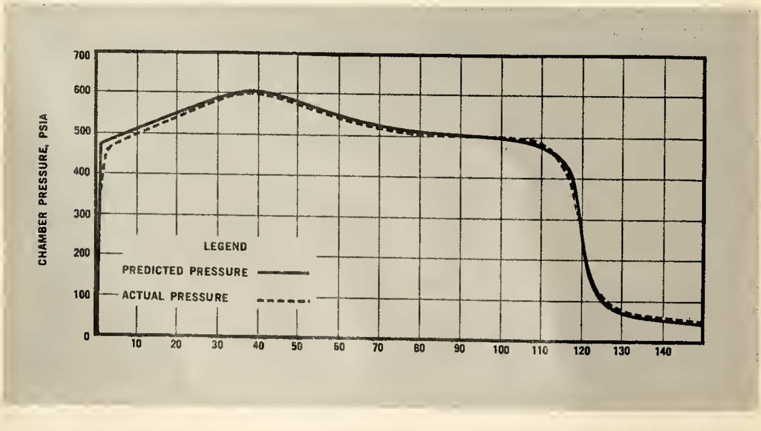
The committee asked Cortright whether ATM would be the only experiment flown on an AAP mission and how much it would cost to build only a satellite for ATM. He replied that the ATM probably would constitute three quarters of the mission and that any price estimates must include launch vehicle costs, including the *Saturn IB*, and the Command and Service Module costs, which are not part of the $80-million estimates.

The space agency still has not finalized either the size or the design of the telescope which will be mounted on the ATM. It is expected that a firm other than the ATM developer will be named to build the telescope. Technical and management direction is also expected to be provided by Goddard.

ATM will be under the overall direction of the Office of Space Sciences and Applications at NASA Headquarters. Dixon Forsythe will head the Headquarters effort. ■

Big Solid Firing Almost Exactly as Predicted

THE ACTUAL PRESSURE CURVE produced by the second half-length 260-in. solid motor firing on Feb. 23 varied little from the predicted curve—even though there was only one other previous test in the program.



Aerojet-General experts confirm that all subsystems closely duplicated the performance obtained in the first firing last fall. The 1,856,980-lb.-thrust motor had an ignition interval of 335 milliseconds and a steady-state operating pressure of 466 psia.

The maximum chamber pressure, recorded at 40.5 seconds into the firing, was 601 psia. This chamber pressure corresponds to a thrust level of 3.51 million lbs.

The motor burned as designed for a web action time of 114 seconds and overall burn time of 129.9 seconds. The ablative throat insert had an average erosion rate during the firing of 0.0048 in. per sec.

The unit burned 1,673,000 lbs. of composite propellant consisting of polybutadiene binder, aluminum powder and ammonium perchlorate oxidizer. ■

Space Activity Projected for FY 2001

American Astronautical Society meeting calls long-term planning crucial to U.S. space future; division of tasks among countries suggested

by William S. Beller

TRAVEL TO NEAR-EARTH planets may be commonplace in the year 2001. For this to occur, a space committee congressman has called for possible division of scientific effort among countries and vastly improved long-term planning.

A matured aerospace industry, by year 2001, also spending much of its efforts as a consultant to governments on major projects out of the field of spaceflight, will have fashioned the necessary technology and interplanetary vehicles.

These events will come to pass only if the strength of the United States—and the world—is not sapped by war and if the Government and its agencies set appropriate long-range goals.

This is the essence of the Fourth Goddard Memorial Symposium, sponsored by the American Astronautical Society (AAS), which tried to sketch the shape of the space age in Fiscal Year 2001. The meetings were held March 15-16 in conjunction with the National Space Club's Goddard Memorial Dinner in Washington, D.C.

Ground rules set—The Fiscal Year 2001 was chosen because it is far enough in the future for contributors to the symposium to think in terms of concepts instead of engineering details. In his keynote address, Dr. Eugene B. Konecci, general chairman of the symposium and staff member of the National Aeronautics and Space Council, said "at least the following should be assumed (for 2001)":

—Unmanned scientific probes throughout the entire solar system and slightly beyond, and long-term reliability of 5 to 10 years;

—Economical space transportation systems based on recoverable vehicles. These may not reduce orbital and transportation costs to less than one dollar a pound, but "certainly . . . down to the order of $10 per pound."

—Economical manned transportation system, either in service or active development, to the near planets;

Vice President Hubert H. Humphrey, speaking at the Goddard dinner which climaxed the symposium, noted the Fiscal Year 2001 theme but would set no timetable for several dramatic achievements in space "that I can visualize." These include:

—Exploration of the lunar surface and possibly establishing one or more permanent bases there;

—Development of a family of Earth-orbiting stations, manned and supplied by regular ferry service;

—Building of spaceports in a number of places in the U.S. for the departure and arrival of spacecraft;

—Development of recoverable and re-usable launch vehicles and maneuverable space vehicles, with a consequent drastic reduction in the cost of space travel;

—Launching of unmanned probes to every part of the solar system—and perhaps manned planetary expeditions as well.

In another vein, the Vice President stressed that the U.S. "can and will achieve the goal set by Presidents Kennedy and Johnson: a manned landing on the Moon before 1970."

Resources limited—The cost of space exploration and exploitation are becoming so big that no country can afford to take advantage of all the opportunities showing up. The U.S. will have to think in terms of long-range objectives for science and technology in order to put space as well as other national goals into proper perspective, Rep. Joseph E. Karth, (D-Minn.) told the AAS.

The congressman suggested that initially the Soviet Union explore Venus and the U.S. explore Mars, as one way to split expenses, to get creditable results, and still not force the countries to work on joint missions.

Karth complained that the U.S. Government is falling down on making adequate plans and reaching decisions on science and technology. "I believe that we . . . need frequent, systematic, large-scale surveys and analyses of science and technology from the near-term to the distant frontiers of knowledge," he said. He added that nobody is effectively doing this job, not even the White House Office of Science and Technology.

The congressman called for a "Hoover-type" commission to undertake a complete review of the relationship between public policy and science and technology. Meanwhile, he promised, "We in Congress are determined to perform an active role in these new areas of human experience—not only in helping to decide where to go, but how to get there." He said that Congress wants not only to look at current budgets but also to see how they relate to plans for the future.

A view of 2001—"The interplanetary flight corridors from Mercury to Saturn are alive with manned vehicles of relatively luxurious and sophisticated design, driven by quite advanced propulsion systems," K. A. Ehricke told the AAS in a graphic description of his view of the promise of Fiscal Year 2001. Ehricke is assistant division director of the Astrionics Div. of North American Aviation/Autonetics.

He said that unmanned probes will have approached the Sun as close as 0.15 AU, and unmanned probes have reached out as far as the planet Pluto. All of this far-flung traffic and the conditions of the vehicles, manned or unmanned, will be continuously monitored by deep-space networks on Earth, by a lunar deep-space control facility, and by an array of relay satellites in near-Earth and cislunar space.

By the year 2001, according to Ehricke, we will have already rendezvoused with the asteroid Icarus and planted an automatic scientific station there. Moreover, astrophysicists will be working in a solar physics station on Mercury; biologists will be running experiments on Mars, backed by well-supplied research and supply stations on the Mars moon Phobos; planetologists will have landed on Venus; and teams of scientists will be studying "what has turned out to be the two most fascinating planets of our solar system—Jupiter and Saturn—from research stations on Callisto and Titan."

Gas-core nuclear rockets—By far, the major development effort in space propulsion technology between 1970 and 2000 will be in nuclear fission rockets, according to Wesley A. Kuhrt, director of research, United Aircraft Research Laboratories.

He noted that solid-core nuclear rockets having specific impulses of 1,000 seconds will have been developed and applied to a wide variety of space applications. This technology plus that gained from high-pressure chemical rocket work "will form the basis for the development of gas-core nuclear rockets having values of specific impulse between 2,000 and 5,000 seconds in the space operational mode," said Kuhrt. ■

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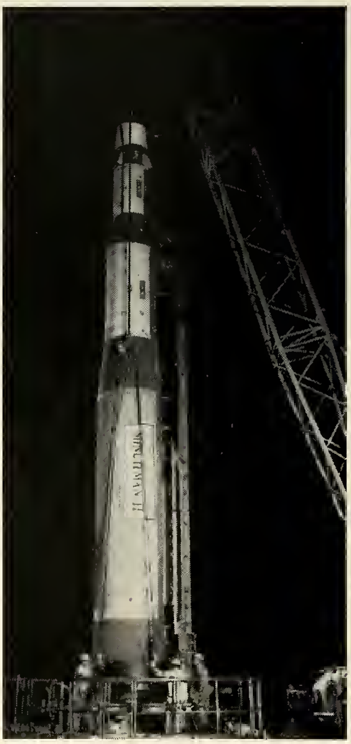

Advanced Minuteman II ICBM incorporates many improvements, including larger payload capacity, longer range, more sophisticated guidance system, increased accuracy.

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Other Divisions: Commercial Airplane • Supersonic Transport • Vertol • Wichita • Also Boeing Scientific Reseach Laboratories

Technical Countdown

ELECTRONICS

Thermionic Power Module Contract to GE

The first phase of a development program for thermionic power modules adaptable to various space mission power level demands will be handled by General Electric Co.'s Missile and Space Div., Valley Forge, Pa. The initial contract, issued by the Albuquerque Operations Office of the Atomic Energy Commission, is valued at about $150,000, but the entire program may reach over $5 million in hardware development. The GE work will involve design and safety studies on polonium 210 and curium 244 isotope fuel systems. The first phase is slated for completion in six months. The following three phases will result in a 100-watt isotopic thermionic module in space. Fuel form and containment research will be conducted concurrently by the AEC's Div. of Isotopes Development.

SECOR Transponder To Be Built by ITT

A multi-attitude transponder will be developed by ITT Federal Laboratories for the *SECOR* satellite. The device will be a receiver and transmitter for accepting ranging, timing and command functions from ground stations and re-transmitting these signals back to Earth. Weighing less than 12 lbs. and having a working life of more than 1 year, the transponder package will be used by the Army to pinpoint ground locations from the satellite. The *SECOR* contract was awarded by the Air Force Geodesy Intelligence and Mapping Research and Development Agency, Ft. Belvoir, Va.

New Antenna Windows Developed

A series of antenna window materials compatible with ablative re-entry vehicles are out of development at Avco Corp.'s Missile Systems Div. The composition of the materials is designed to minimize trace impurities of alkali metals and alkaline earths. This reduces boundary layer contamination by undesirable species affecting radar transmission. Windows fabricated from the new X-9000 series have been successfully tested in two Air Force experimental flights down the Atlantic Missile Range.

SPACE SCIENCE

Satellite Triangulation Teams Operational

Four-man American satellite triangulation teams in Greenland, Iceland, Norway, Scotland and Denmark are gathering data leading to more precise distance determinations on Earth. Using the *Echo* satellites and the coming *Pageos* satellite, the teams will tie the North American and European continents together by establishing a mathematical base. This base will allow surveyors to pintpoint exact horizontal and vertical positions on the two continents with respect to each other. Another team has been in operation in Canada for over a year. All of the involved governments are cooperating with the U.S. Coast and Geodetic Survey effort. The *Pageos* satellite launch, scheduled for June, will initiate work on a world-wide, 41-station geodetic satellite network.

PROPULSION

NASA Funds LPC Liquid Solid

The Lockheed Propulsion Co. concept of a commanded stop-start-throttleable solid using a reactive liquid injection scheme will be evaluated by the Redlands, Calif., firm under a $96,000 contract from NASA. The contract will be managed by the Jet Propulsion Laboratory and research results from 18 engine test firings will be presented to the Chemical Propulsion Div., Office of Advanced Research & Technology. Basic idea of the Lockheed engine is to use a solid propellant with a high-pressure effect on the burning rate and a nozzle sized so that the propellant will cease burning in the absence of fluid flow. A reactive liquid injected into the combustion chamber initiates and sustains combustion. Varying the fluid flow results in thrust termination or modulation.

Hercules Perfects Hot Gas TVC Valve

A 35 lb./sec. actuated, propellant gas valve for use in chamber-bled, secondary-injection, thrust-vector-control systems on large boosters is in excellent operating condition after a series of tests. Developed by Hercules Powder Co. engineers at Allegany Ballistics Lab, the valve was tested both at ABL and on the 84-in. char motor at Edwards AFB, Calif. The motor operated 108 seconds at an initial pressure of 730 psia (valve closed) and 528 psia (valve open). The valve completed 10 leak-free cycles during this period. Four additional cycles were performed during the tail-off portion. Valve flow passages showed no localized erosion or uneven flow patterns. The program was sponsored by NASA.

LIFE SUPPORT

Animal Flights Yield Weightlessness Data

Weightlessness effects on the inner ear, the central nervous system and orientation sensing mechanisms in the neuro-muscular system are being studied at Ames Research Center in parabolic flights of T-33, F-104 and F-4 aircraft. Special instrumentation is being used on cats, rats and monkeys to measure electrical signals of contraction force of basic muscle units and of muscular reflexes, as well as the discharges of a single otolith unit.

SPACE MEDICINE

New Lab Aimed at Space Visual Problems

A recently completed high luminance vision laboratory at Ames Research Center will be used for a wide range of research on the problems of seeing bright objects from various distances in space. Basic component of the laboratory is a dust-free clean room to avoid light-scattering effects. Equipment will include various short- and long-look shutters, target models and other equipment. Researchers will be able to monitor such things as eyeball position, electrocardiogram, electroencephalogram and other physiological reactions.

Drinking Man's Diet Revisited

Studies of fat as a major item of an astronaut's diet are being carried on at the Ames Research Center with the aid of healthy male volunteers between the age of 21 to 43 years. In one experiment, Dr. Donald R. Young reports, it was shown that up to half of total calories supplied to inactive workers can be in the form of fat. Up to 1½ lbs. of fat can be consumed, without undesirable effects, by individuals engaged in extensive activity, he found. Radioactive tracers to study the mechanisms of the high fat use by the body indicated that carbohydrates were being produced.

Vacuum Freezing Effects Probed

Atlantic Research studying phenomenon for MSC following GT-5 thrustor problem; three-phase attack under way on Apollo system to determine effects on ignition

by John F. Judge

APOLLO PROPULSION hardware is being examined by Atlantic Research Corp. scientists to determine the effects of an insidious space hazard—the freezing of liquid when exposed to hard vacuum.

The end result of this freezing could mean clogged dump lines, accumulation of solid mixtures of fuel and oxidizer on superstructure, plugged injection heads and accumulation of frozen liquids in the combustion chamber. This last item could result in a hard start for the engine, a condition which often leads to combustion instability.

ARC specialists told MISSILES AND ROCKETS that the parallel redundancy designed into the *Apollo* spacecraft propulsion system may prove equal to the problem—unless both subsystems leak enough liquid to result in clogged lines.

The firm probed the fundamentals of the phenomenon under contract to Marshall Space Flight Center some time ago. The current contract covering the *Apollo* hardware is with the Manned Spacecraft Center.

Gemini program people consulted with ARC after the minor 25-lb. thrustor problem on *GT-5*. The ARC team under Michael Markels, Jr., concluded in a quick theoretical study that freezing was not the main problem although the *Gemini* system could have functioned in a self-curing mode if frozen propellant had gathered in the injector area.

The problem is different in both the *Apollo* mission and space station programs such as the *Manned Orbiting Laboratory*.

The present contract is a three-phase attack on the *Apollo* system. The first two sections involve analyzing the fuel and oxidizer systems and the liquids themselves. The third phase takes the results of the previous work and applies it to the effects on ignition and possible suppression of kinetics and determines the leak rates with respect to filling the combustion chamber with frozen propellants.

Mechanics of freezing—The exposure of liquids to vacuum involves a variety of phenomena, most of which result directly or indirectly from the suddenly imposed supersaturation. Volatile liquids exposed either in bulk or by leakage usually boil. The growth and bursting of bubbles breaks the liquid into a cloud of vapor and droplets.

Surface forces as well as the turbulence and other disturbances created by the flow of the liquid also contribute significantly to the breakup. Bulk quantities of non-volatile liquids also usually boil on exposure but jets formed by leakage of these liquids do not boil. ARC experiments show that breakup still occurs due to surface forces and turbulence.

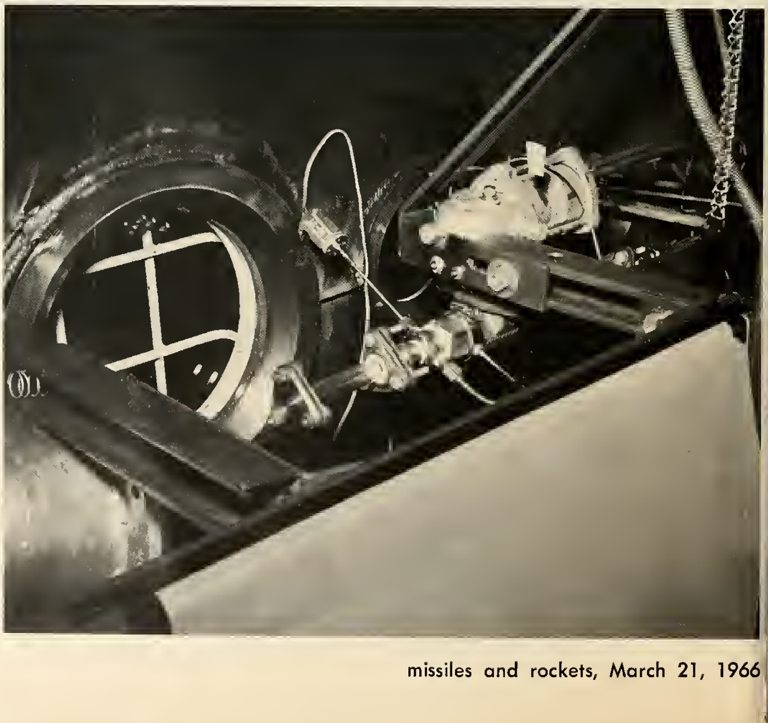
For either type of liquid, the initial velocity resulting from the breakup process, together with any velocity acquired by expansion, disperses the droplet-vapor cloud in all directions into the vacuum.

Simultaneous with breakup and dispersal, evaporation occurs from all free surfaces of the liquid. ARC analysis shows that the rate of evaporation into a vacuum depends primarily on the surface temperature and the nature of the liquid. It is only slightly dependent on the concentration of the evolved vapor above the interphase.

In addition, the rate of evaporation of most liquids at or above their triple-point temperature is large, as is the evaporative cooling since latent heat is removed. The evaporation cooling rate is typically in the 1 to 2,000 calories /cm^2-sec.

On the other hand, considering a space environment of an experimental vacuum chamber, the heating of a free mass of liquid by outside sources is generally by radiation alone at a rate several orders of magnitude less than evaporative cooling.

Rapid process—Even if the liquid is not free, but is adhering to some surface, heating rates are still usually



comparatively small.

During the initial moments of exposure, the latent heat of evaporation is supplied almost entirely by the sensible heat of the liquid itself. As a result, the liquid cools and freezes.

In the many situations in which the sensible heat is transported to the surface by conduction alone, analysis shows that cooling is non-uniform and concentrated at the surface. After the surface has cooled to the triple-point temperature, freezing commences and progresses towards the center of the drop as evaporation continues.

ARC researchers found these extremely rapid. Small masses—up to a few millimeters in size—of most liquids are totally frozen within a fraction of a second after exposure.

The total lifetime of a liquid mass in a vacuum is much longer than the duration of the cooling and freezing phase. Because the evaporation rate is a function of the surface temperature, evaporation during the first moments of exposure proceeds at a continually decreasing rate.

Eventually, the liquid cools to a sufficiently low temperature where cooling by evaporation balances the heating from outside sources. The remainder evaporates away (or sublimes, since most liquids will have frozen before this state is reached) at a constant temperature.

Since the heating rates are usually small, the remaining liquid or frozen solid persists for a long time, up to 10^4 times the duration of the initial cooling and freezing phase.

Since the dispersive forces causing the breakup of bulk quantities of liquids are not too intense, the drops range in size from a few hundred microns to several millimeters. But the high velocity flow which may accompany leakage results in more intense dispersion forces and the droplets are smaller.

Plug formation—Volatile liquids appear to boil in the leak hole or near its exit and liquid emerges as a conical spray of drops. The included angle of the spray cone for cryogenic liquids is approximately 180 degrees.

Mass flows through leak holes and vent lines into a vacuum are never greater and usually less than those for discharge into a normal atmosphere. The vacuum may cause volatile liquids to boil in both leak holes and vent lines and the simultaneous flow of the less dense vapor produces a lower-than-normal mass flow rate.

If the flow rate is sufficiently small, freezing may occur in the hole as well and the flow of liquid is completely reduced or stopped by the solid formed. Complete stoppage was observed at ARC for only very tiny leaks.

Preliminary analysis indicates that a plug can form, stopping the flow only if the flow velocity is less than the linear evaporative freezing velocity of the liquid, which is less than 50 cm/sec. for most liquids.

Discharge of liquids from vent lines produces a solid formation of some type about the exit. Although the flow may be partially blocked, it is never completely restricted. But if the flow is interrupted, a plug of evaporatively frozen solid forms in the end of the line within several seconds. This is not the case with cryogens since their flow seldom fills the lines.

Plugs thus formed can resist considerable pressure if they have adequate footing—a condition existing in the case of liquids expanding when frozen such as water or if the line is constricted.

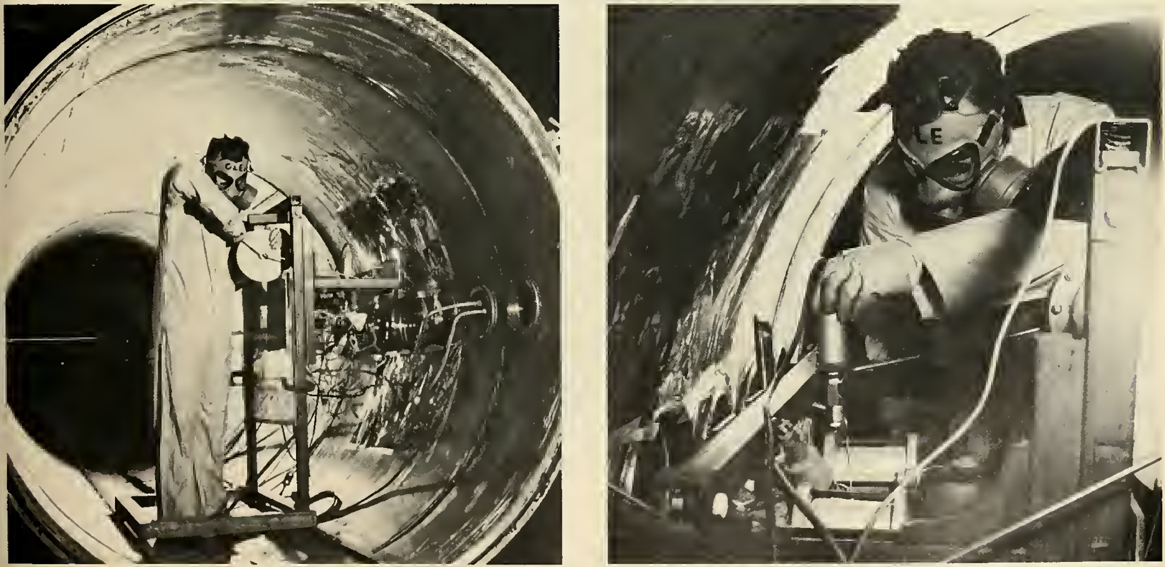
In such cases, flow may not resume merely as a result of reopening a valve. In one instance, a plug of ice formed in the end of a 0.5-in.-dia. glass tube after the water flow ceased. In 30 seconds, this plug had attained sufficient strength to resist the resumption of flow under a pressure of 50 psi.

Much of the theoretical work to date at ARC has been verified experimentally. There are several basic areas left to be explored more thoroughly. It is axiomatic that all valves leak to some degree and the effects of the vacuum-induced freezing could go a long way toward completely disrupting the carefully planned space mission of some duration.

The current program simulates the *Apollo* propulsion system functions. The next logical step is full-scale testing of *Apollo* hardware, specifically the service propulsion system unit. The Lunar Excursion Module propulsion units are also involved in the program.

The *Apollo* system uses nitrogen tetroxide and Aerozene-50. Since the fuel is a mixture, the freezing rate process is significantly more complex than with the oxidizer.

ARC experts expect to be able to provide concrete solutions to any vacuum freezing phenomenon in the *Apollo* system. The redundant design approach taken by North American Aviation's Space and Information Systems Div. may avoid the possible problems posed by frozen liquids. ■



The Apollo service propulsion system propellant valve and injector assembly is simulated in the ARC vacuum tank (left). Injector plates with various hole patterns are attached to a section of glass pipe which serves as the injector manifold and visual flow passage between the propellant valve and the injector. Exact leak rates are set up by adjustment (right).

30,000 of these

The rate gyro on the left is either an H3 or an H4 (they look alike).

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went into this.

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About the only thing that isn't new and better about the G5 is the shape.

It didn't seem to need improving.

NORTHROP

Northrop Nortronics Division
Precision Products Department, Norwood, Mass.

Track Plans Mach 6 Nose Cone Tests

Holloman has already conducted rocket-powered sled experiments on broad scale; aim is to simulate effects of nuclear blasts

by Rex Pay

HOLLOMAN AFB, N.M.—Track facilities here are being upgraded to enable tests of the effect of blast and impact on rocket nose cones traveling at Mach 6 and faster.

In a recent test, a 9-in.-dia. third-stage rocket propelled a nose cone at just over Mach 6 into a 2-ft.-thick reinforced concrete target. The nose cone, carrying a solid tungsten tip, penetrated the target, which was disintegrated into pieces no larger than a fist, thrown as far as a mile away from the impact point.

Main body of the cone was machined aluminum. The experimenters sought to measure how fast the impact shock wave travels through the material. Somewhat similar tests at slower speeds (4,000 ft. per sec.) have been carried out with *Pershing* warheads to verify that the fuzing system functions in correct sequence as the nose cone plunges through a block of reinforced concrete.

To test the blast effects of nuclear weapon bursts close to an incoming warhead, the Directorate of the Test Track Facility here plans to drive a nose cone to Mach 6 on a monorail sled, separate it, let it fly through the blast wave from several thousand pounds of TNT, and catch it in a bin full of sand and sawdust.

Capt. G. A. Carew told MISSILES AND ROCKETS that the bin will be 300 ft. long, 8 ft. tall and 8 ft. wide. The first section will contain sand, the second sawdust. The nose cone may come out of the end of the bin, said Carew, but at quite low speed.

The blast waves may eventually be produced by the detonation of as much as 80,000 lbs. of TNT, but there is currently no requirement for this degree of intensity.

The Holloman 35,000-ft. captive missile test track carries sleds powered by rocket engines of up to 105,000 lbs. thrust. A program to develop a sled powered by a 300,000-lb.-thrust *Titan II* engine has been dropped.

Of the two continuous forge-welded rails, the west one is the master, and is aligned to within 0.005 in. of a fiducial line. The east rail is aligned to within 0.01 in. of the west one. Both are made up of 171-lb.-per-yard crane rail. The north end of the track is some 35 ft. higher than the south end, as the track has a minimum radius of curvature of one million feet.

Blast effects programs—Two blast-testing areas are being readied for future programs. One, the captive blast site, is located on the west side of the track, 13,000 ft. from the start. The other, the free-flight site, makes use of a new 500-ft. extension at the north end of the track.

At both sites the surrounding area has been leveled and asphalted to allow uninterrupted propagation of blast waves. The 13,000-ft. site is for Navy tests and will involve the use of a new Mach 3 "outrigger" sled. The main body of the sled carrying the test nose cone moves over the west rail, but increased stability is gained by use of an outrigger that carries a slipper on the east rail.

Previously, it has been difficult to get up to Mach 2 with a dual-rail sled, and the new sled represents a considerable step forward in track testing technology. It has a wedge extending in front of the main body to reduce drag. The nose cone to be tested projects above this.

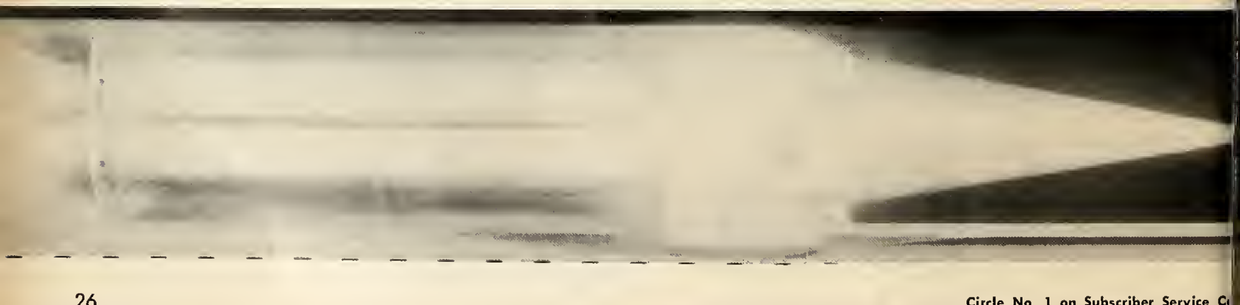
Behind the nose cone are ballute and parachute compartments that house the main air-braking mechanism for the sled. Behind the wedge, in the main body of the sled, is a telemetry pallet. A camera is carried in a pod on the outrigger, which is in the form of a cambered wing. Construction is aluminum monocoque.

First-stage power for the sled is a cluster of 8 Terrier rockets; second stage is made up of four Recruits. These stages are brought up to initial speed by means of two pusher sleds. Testing is due to start in May or June of this year. Water bags on the track will act as the final brake.

Limitations—As this outrigger sled cost about $90,000 and the track itself represents a substantial investment, the blast testing at the captive site will be restricted to levels that do not cause damage to the track or sled that cannot be readily repaired. So far 1,500 lbs. of TNT detonated at a distance of 400 ft. from the track is the maximum level tested. It is thought that 8,000 lbs. may be the maximum that can be used at this site.

One very crucial problem is making sure that the nose cone and the blast

Shadowgraph of recent Holloman sled test of typical nose cone, propelled by four Recruit motors, traveling at Mach 3.



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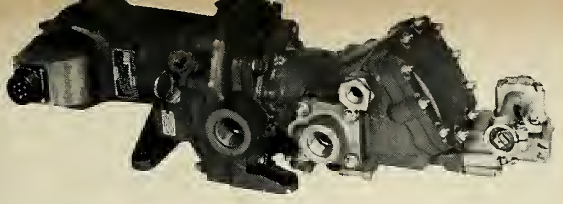
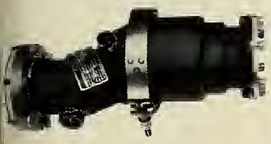


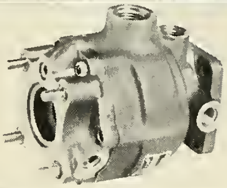
Motorpumps, including integral gearboxes when required, for secondary power applications on aircraft and missiles combine reliability with light weight.

Auxiliary power units for primary and secondary fluid power systems are available in modular and completely integrated designs.

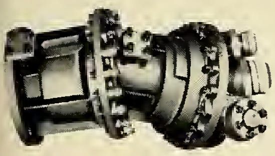


Hot gas motorpumps operate on bi-propellants and solid propellants for primary and secondary control power in missiles and space vehicles.

LOOKING FOR PROVED FLUID POWER AND CONTROL?

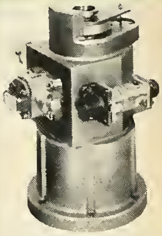


Vane-type fuel pumps offer high efficiency, high output and speed capability, significant weight reduction and meet severe contaminant tolerance specifications.



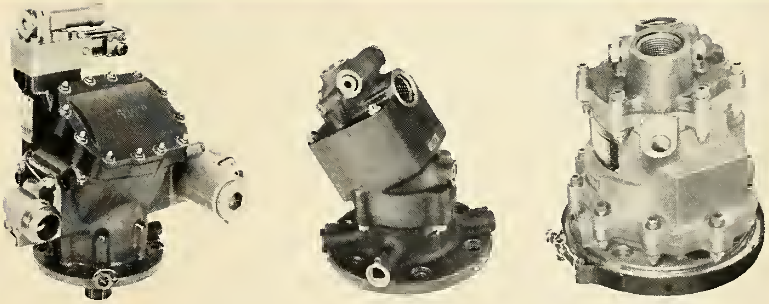
High temperature pumps like this are now operating on mineral-base fluid at 450°-550° fluid temperature and 3000 psi outlet pressure. Feasibility studies have been completed on pumps for future systems to 1200°F.

Compact, hydraulic starters perform repeated starting cycles and permit motoring of engine for extended periods. Also provide hydraulic pumping mode during flight.

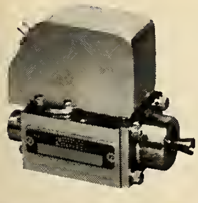


Servo-actuators, like this one for rapid tuning of microwave transmitters, handle a wide range of precise positioning tasks.

Single-stage, hot gas pressure regulating valve that controls combustion pressure of solid propellant gas generator is typical of complete line.



Yoke-type, fixed-angle and in-line variable displacement pumps combine millions of hours of inflight operation, let you choose the best pump for the application.



Pulse modulated rocket motor delivers to 6 pounds of thrust, requires 8 to 10 times less power input than previous state of the art.

For more details on these and many more applications, write for Bulletin A-5283A "Harnessing Fluids for Airborne Uses." Vickers Incorporated, P.O. Box 302, Troy, Michigan 48084.

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wave meet at the correct time. At present, Command Nuclear, contractor to the Navy for this project, is examining ways of synchronizing the arrival of the blast front with the arrival of the sled. Tests to measure the transit time of blasts to the track will be made prior to runs to see if predictions are reliable. Quite probably the spot velocity of the oncoming sled will have to be measured and the detonation time computed as a function of this in real time.

First feasibility test of a 1,500-lb. detonation produced a 40-millisec. pulse of 3 to 4 psi overpressure at the rail, but the sled missed the maximum intensity of the shock wave.

Another method of simulating the effect of a nuclear blast investigated was to allow a sled traveling at about 3,000 fps to plow through plastic bags filled with Freon. This gas has a density seven times that of air, but its simulation of impact loading was not sufficiently realistic.

Mach 6 sled testing—In going for speeds of Mach 6 and higher, Holloman is pushing past its own land speed record. According to the director of the Track Test Facility, Col. Lawrence H. Ballweg, sleds have been run at 6,300 fps and have approached 7,200 fps in one impact test. "We'll get up to Mach 6, I'm sure—and higher, possibly," he commented.

All sleds run on steel slippers and one of the chief problems at very high speeds (above 5,500 fps) has been melting of the slippers due to aerodynamic friction, frequently with subsequent gouging of the track. The scar on the track then has to be filled with weld material and the surface ground down to tolerance again.

One design approach being tried is to open up the inner area of the slipper to reduce the internal pressure loads. Canard surfaces may also be used on the sleds to control aerodynamic loads. A contract for development of air-bearing slippers will be let soon.

One of the biggest problems in Mach 6 testing is stopping and recovering the sleds. This is why the highest speed has been registered in an impact test. The scattering of debris from such an impact out to distances of a mile or more means, however, that cameras must be located a long way from the track and that data collection is difficult.

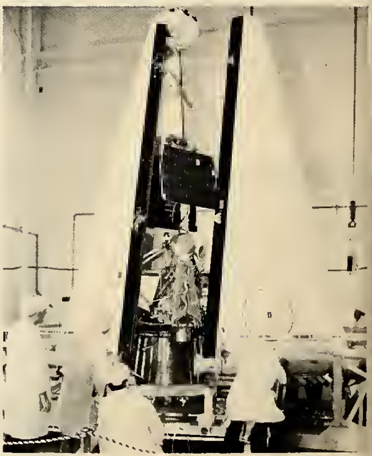
The blast effects tests with the Mach 6 sled will be carried out for the Air Force Weapons Laboratory, Kirtland AFB, N.M., and are due to start at the north end of the track in the late summer.

The Mach 6 sled is a monorail sled, about 2 ft. high, with an ogive-shaped cone at its fore end. It will be brought up to speed by two pusher sleds, two Terrier rockets, and four Recruit rockets. The explosive levels at the north end of the track will be much higher than at the captive site.

One of the chief problems is in separating the nose cone from the sled. One approach being considered is separation of the two with an explosive charge that deflects the trajectory of the sled as it leaves the end of the track. The nose cone would then fly on unencumbered to meet the shock wave from the exploding TNT. There will be instrumentation in the nose cone and the recovery of the cone is considered important, hence, the 300-ft.-long catching bin.

Another form of test that is being considered is to separate the nose cone at about Mach 3.5 and fly it through an 8 x 8 ft. shock tube. As the cone enters the tube, a plane charge at the far end would be detonated to propagate a shock wave down the tube towards the cone. The tube would be made out of 1-in. plywood with metal straps. ■

First Surveyor Nears Mating



Initial Surveyor flight spacecraft, built by Hughes Aircraft Co. for NASA, shown in halves of its nose cone prior to test-mating with its Atlas-Centaur booster at San Diego, Calif., plant of General Dynamics/Convair, booster contractor, where it was recently delivered. Spacecraft will later be delivered to Cape Kennedy for final launch preparations, with firing presently expected sometime in May. Early Surveyors are test models heavily instrumented to measure performance of the spacecraft and ensure development of lunar soft-landing capability. Hughes has contracted to build seven for NASA's lunar-landing programs.

Longer Manned Flights Now Seen Safe

by Heather M. David

AIR FORCE PHYSICIANS are concluding that enough knowledge now exists to ensure the physiological safety of astronauts on spaceflights exceeding one month if currently available protective devices are employed.

Indications from recent statements are that centrifuge devices for the *Manned Orbiting Laboratory (MOL)* are losing favor with top Air Force aerospace medical experts, except for research.

Dr. Lawrence E. Lamb, one of the top cardiovascular experts in the aerospace medical field and chief of the Aerospace Medical Sciences Div. of the School of Aerospace Medicine, recently ventured that spaceflights even considerably longer than one month might be accomplished safely with "proper use of hypoxia, isometric contractions for maintenance of muscle tone, acute short-term application of lower-body negative pressure in the presence of adequate salt and water intake, and, if need be on landing, pressure garments."

Another group of Air Force doctors at SAM recently reported that use of a drug, 9-alphafluorohydrocortisone, for a two-day period after prolonged bed rest showed promise in repleting blood plasma volume losses. These losses appear to be keyed to the "orthostatic deconditioning" of circulatory problems noted in long-duration spaceflights.

Hypoxia—The use of a slightly oxygen-rare gaseous mixture—like that at an altitude of 10,000 ft.—has been found beneficial in decreasing problems with the circulatory system as well as being the only known way to prevent calcium mobilization or loss of calcium from the bones and muscles of individuals in the simulated weightlessness of bed rest.

Scientists at the school found that the decrease in red cell mass which usually occurs with four weeks of bed rest did not occur when the subjects spent the time at a simulated altitude of 10,000 ft.

At a simulated altitude of 12,000 ft., the scientists found, the red cell mass was increased. A decrease in red blood cell mass has been a medical finding on the *Gemini* spaceflight missions (M/R Jan. 3, p. 16).

It also was discovered, however, that while loss of calcium in the urine was about the same for hypoxic and bedrest subjects during the first three weeks, on the fourth week there was a decrease in calcium loss in the hypoxic group.

Only minor changes in levels of calcium excretion were noted in the hypoxic subjects after four weeks—compared with their usual ambulatory levels—with six out of eight subjects back to normal.

Lamb pointed out that hypoxia also creates a workload on the circulatory system, another beneficial effect for long-duration weightlessness.

However, hypoxia does not have a favorable effect on the level of hydration or blood plasma volume, other aspects of the circulatory problem which have been attacked by the school.

Lower-body negative pressure—The problem of dehydration which has occured in every single U.S. manned spaceflight is suspect by many physicians as the cause of the orthostatic hypotension which showed up in longer flights of six or more obits. This condition caused near fainting in one astronaut, pooling of blood in the legs in another and measurable changes in heart rate and blood pressures in tilt table measurements made after recovery in all astronauts.

In one of Lamb's studies at SAM, four subjects were confined to bed rest until a decrease in fluid balance, body weight and plasma volume occured.

The subjects were then put in "boxes" in which the lower parts of their bodies were exposed to negative pressure of 30 mm Hg. A airtight rubber seal ensured that the effect was kept to the lower half of the body.

The use of lower-body negative pressure has the effect of drawing the blood into the lower portion of the body. The action appears to have an effect on the circulatory system of the lower body similar to that of standing.

The SAM study indicated that two days' use of intermittent lower-body negative pressure could restore the level of hydration if careful attention were taken to intake of water and salt.

SAM physicians note the importance of this finding to manned spaceflight. If astronauts have problems involving hydration and the effects on orthastatic tolerance, it may mean that these conditions can be improved greatly just before leaving orbit. Lamb, in fact, has indicated that it would make no difference whether the flight were of five-days or five-months duration. The short treatment time would take place only at the end of the flight immediately before leaving orbit.

This, Lamb points out, would be similar to the situation in which hospital patients return to normal fairly rapidly with gradual ambulation after prolonged bed rest.

However, lower-body negative pressure has its limits as a cure-all since there are no apparent effects on red-cell mass, bone marrow function or calcium metabolism.

Medication—Another group in the Internal Medicine Branch at SAM recently reported a study of four healthy subjects confined to six days' bed rest.

In this study, metabolic changes were measured after the six-day period. It was found, as expected, that plasma volume had decreased. A second run was made with the same men, but after four days, two milligrams of alphafluorohydrocortisone was administered daily.

It was found that weight increased during this time, plasma volume began to increase to previous levels, and water and sodium retention occurred. No deleterious side effects were found from the 9-FF use.

Other methods—Use of a pressure garment—a g suit or even a Jobst stocking—at the end of a spaceflight may be effective against possible significant decrease in orthostatic tolerance.

Exercise may counteract some of the adverse effects, but generally is being ruled out as sufficient by itself.

In general, the Air Force group is taking a very optimistic view about man's ability to cope with long-duration flights. During the flight, the only problems even likely, Lamb indicates, are formation of renal stone or progressive decalcification of the skeleton.

However, the low amounts of calcium which actually have been mobilized make stone formation fairly unlikely. Danger of demineralization from the skeleton can be assessed in terms of clinical experience, where in even very long periods of immobilization, decalcification does not occur to such degree to prevent fracture healing or recovery.

And as far as tolerance to re-entry forces after a month in orbit, subjects in a SAM study of complete bed rest for four weeks with no countermeasures were able to tolerate 10.6 g's acceleration on the centrifuge immediately after confinement without difficulty. ■

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GPK-33—**For Space Boosters**—This is a small, compact, ruggedized computer similar to the ASN 24. It is an integral part of the Centaur inertial guidance system and generates steering and engine cut-off signals based on the output of the gyro-stabilized platform.

And there are more—A microelectronic version of the AN/ASN 24 designated L90-1B is in flight test. A DDA computer similar to the MINAC series, utilizing microelectronic circuitry, is being flown. And then there is the new generation now being designed.

We want to tell you more about this lively field of airborne computers, so just drop us a line soon.

NOTE: *MINAC is a family of hybrid computers combining the best features of state-of-the-art analog computers with high accuracy digital integration. Versions have been produced for Doppler and inertial platform inputs and for display in latitude/longitude or UTM coordinates. Digital output for data annotation is also available. All computers in this series include field replaceable modules and self-test features.

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Scientific Data Systems Aims At Bigger Share of Market

by Charles D. LaFond

NEW YORK—A "third-generation" general-purpose digital computer development, called the Sigma 7 series, was revealed here last week by Scientific Data Systems.

Disclosing that Sigma 7's universal-type internal design will permit a single computer complex to handle research, engineering, business and process-control problems for up to 200 users simultaneously, SDS effectively made known its intention to compete directly with the industry leaders.

SDS President Max Palevsky stressed the market attributes of the systems, which will be priced in the $200,000 to $1-million range:

—Each computer configuration will outperform by a factor of three any existing systems in the same price class;

—Each computer configuration will cost 50% less than any existing system offering the same capability.

First actual hardware showing of Sigma 7 will be at the Spring Joint Computer Conference next month in Boston, Palevsky said. First system deliveries, he claimed, will be made late this year.

Fundamental design change—SDS describes its new series as representing the first fundamental conceptual change in computer design since development of the early electronic data handling systems of the 1940's.

The result of a two-year development program, Sigma 7 is designed for real-time computation while operating in time sharing, multiprocessing and multiprogramming environments. Considered by developers a third-generation computer, Sigma employs over 90% monolithic integrated circuits in its active-circuit assembly; all were designed by SDS engineers.

Memory capacity of the system is expandable from 4,096 to 131,072 words (to 524,288 bytes), memory cycle time is 1.2 µsec. (or 700 nanosec., effective cycle time when overlapping occurs). Word size is 32 bits plus parity (in four 8-bits bytes). Maximum memory module speed, the firm claims, is 26 million bits/sec. From 16 to 512 registors may be employed, expandable in blocks of 16. Typical instruction execution speeds, which include indexing, mapping, and memory overlap, were stated by SDS officials as: (in µsec.) load word, 2.0; add, 2.0; multiply, 4.9; and, divide, 12.5.

Up to 256 input/output devices may be employed with input/output data rates to 160 million bits/sec. Designed for compatibility with IBM systems, Sigma 7 will accommodate a variety of programming systems—FORTRAN, PL/1, Sigma Assembler, Meta-Assembler, Control Monitor, Batch Monitor, Universal Monitor and Library.

A completely modular memory is employed with no central stack. Instead, the central processor is comprised of plug-in printed integrated-circuit cards, supported by many minor processors—each capable of individual repair without causing system downtime, developers said.

Sigma 7 design goals—SDS, said Palevsky, sought to solve the limitations of existing computer hardware by drastic reorganization within the computer. The real need today, he stated, is to amplify man's intelligence and mental processes by machine. The concept involves not just how fast the machine can turn out data but how well it can assist man in performing each specific task.

The need exists, he stressed, for direct interaction of man with machine. In addition, the need exists to tie many users to a single machine to obtain maximum use of computer subsystems capability and to reduce programming complexity. Over 50% of present machine use, he pointed out, is spent just in program debugging.

The firm believes its new Sigma 7 series answers these problems. Market plans call for sales of $300 million with Sigma 7 during the next 5 years and an increase from its present 2% of the total market to 3%. Three to five systems will evolve in the Sigma 7 series ultimately, the firm said, with a probable trend downward to more economic system configurations. ■

Typical Sigma 7 configuration includes (from left) card punch and reader, central processor, teleprinter, operator console, two magnetic tape units and printer. It represents first fundamental change in computers since early electronic data systems.

Continental Shelf Survey Promising

First comprehensive study of Atlantic shelf and slope ending; three-part effort includes sub-bottom profiling, ocean drilling; Geneva agreement sharpens interest

by Robert W. Niblock

PRELIMINARY FINDINGS of a current geological survey of the Atlantic continental shelf and slope indicate there may be large deposits of phosphite, manganese oxide, petroleum and sand.

The first comprehensive survey of the shelf and slope, comprising about 316,200 sq. mi., is nearing completion. According to Dr. Gilbert Corwin, director of marine geology and hydrology for the U.S. Geological Survey, a wealth of new data has been gathered. One report states that the Blake Plateau, a geological formation off the southeastern coast of the U.S., is literally paved with manganese ore.

The five-year study is a cooperative effort of the Geological Survey and the Woods Hole Oceanographic Institution. Although short on funds and manpower, the two organizations have cooperatively succeeded in covering the shelf and slope from Nova Scotia to the southern tip of Florida, making geologic, hydrologic, biologic and geochemical studies.

Woods Hole has received about $300,000 annually under a Geological Survey contract since the summer of 1962 when the study commenced. Another $200,000 is spent each year to support Geological Survey participation. Project director is Dr. K. O. Emery, a marine geologist at Woods Hole, who conducted extensive studies of the Pacific shelf while at the University of Southern California, then proposed the plan for an Atlantic shelf study.

The Geological Survey agreed to fund the plan, said Corwin, because "geologic and hydrologic knowledge of coastal areas and the ocean floor is fundamental to our understanding—and to the evaluation, exploitation and conservation of nearly all ocean resources."

First comprehensive study—Although a variety of studies have previously been performed on the shelf, the current one is described as the first truly comprehensive examination. In their study plan, the scientists said that they expect the results to "have considerable application to future recovery of oil and gas and to mining of such sea-floor deposits as manganese and phosphorite."

Corwin said the study should not be construed as a search for specific deposits of minerals, noting that the oil industry, for example, "doesn't want us publicly reporting on major oil deposits. They want to do their own looking, drawing on the broad kind of geological information we can provide."

Three-part survey—The study of the shelf and slope was divided into three broad phases: a survey of existing literature; actual reconnaissance of the area; and the drilling of deep holes.

Although phases one and two are nearly complete, the study timetable was pushed back when Geological Survey scientists were called off the project to participate in the successful drilling of six holes between 18 and 250 mi. off the northeast Florida coast. The holes were drilled by the Joint Oceonographic Institutions Deep Earth Sampling program, yielding cores of rock formations from nearly 1,000 ft. below the ocean floor.

During the first year of the study, most work centered on the preparation of laboratories at Woods Hole, modificatin and outfitting a Woods Hole vessel for marine geological studies and analysis of existing data and samples.

The combined manpower committed to the study by Woods Hole and the Geological Survey includes 19 scientists, 10 sub-professionals, four clerical workers and a few part-time personnel.

A converted 118-ft. Army freighter, renamed Gosnold, is the principal research ship for the operation, with support from the smaller research ship, Asterias.

Teams of six scientists were ordinarily assigned to the ships, working three shifts during an average of 100 days per year at sea aboard the Gosnold. The Asterias is used about 60 days annually.

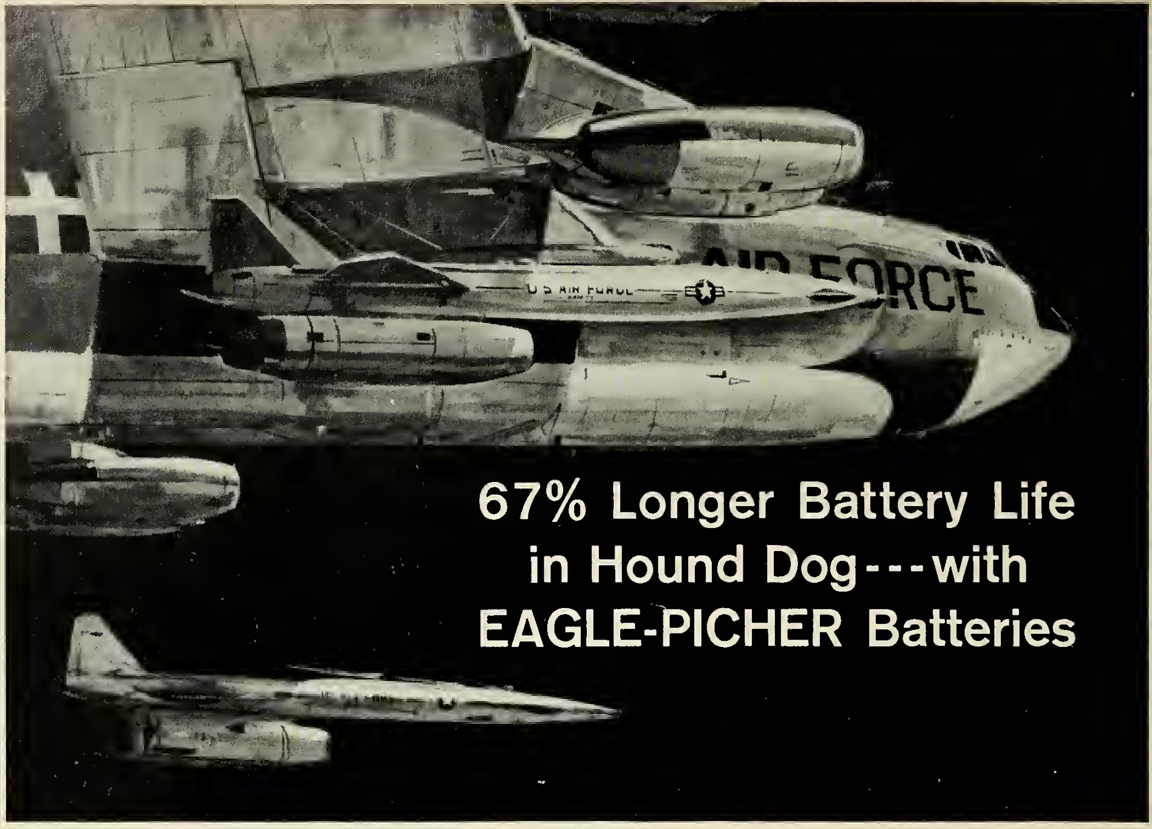
Shipboard operations began in the summer of 1963. The work then was to systematically sample sediments with a grab sampler, a bucket-shaped device tethered on a cable. Mounted within the grab was a camera to photograph the bottom just before the device touched bottom. More than 2,000 such samples were taken at 10-mi. intervals over the entire shelf and slope. This phase of the effort is finished.

Sub-bottom profiles—The second phase of the work at sea, sub-bottom profiling, is also nearing completion. Using a "sparker"—an electrical sound source which creates an acoustic pulse that penetrates sediments to a depth of 1,000 ft.—the scientists covered the entire area at 30-mi. intervals.

Corwin says they expect to have a "print out" this month of the data assembled during the bottom-sampling phase. He is now working with the National Oceanographic Data Center in Washington, D.C., in an attempt to establish a format to include marine geological samples in their oceanology data bank. "We are trying to simplify our input to them, so they won't be so bogged down with information that they can't handle smoothly on an output basis." Oceanology data at NODC is shared with the scientists of cooperating nations throughout the world.

Ocean drilling next—When the sub-bottom profiling is done, Corwin then plans to divert about $100,000 now being spent annually for ship operations to drilling deep holes, some up to 1,000 ft., on the shelf and slope. This work will be done under contract by one of the experienced companies in ocean drilling, Corwin said. "We expect to drill several holes, which will no doubt yield valuable information on the rock formations below the ocean floor."

Interest in the possible exploitation of the continental shelf has sharpened in recent months, due in part to the ratification of the Geneva Convention on the Continental Shelf. This agreement, in effect, confirms the right of a nation to explore and exploit the natural resources of its own continental shelves out to a depth of 750 ft., or deeper if practical exploitation can be done. Practical exploitation is, of course, in many ways dependent on the ability to live and work at great depths. Two successful Sealab experiments lend credence to belief that man can be used for this purpose. ■



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The Industry Week

Aerospace Employment Gain Predicted

Employment in the aerospace industry is expected to reach a total of 1,266,000 by June, a gain of 8% from September, 1965. Results from a current survey by the Aerospace Industries Assn. show an increase in missile/space employment of 4,000 for the nine-month period. The number of scientists and engineers in the industry is expected to rise from 201,000 to 215,000 for the period, a gain of 7%.

Mergers and Acquisitions

LTV Ling Altec, Inc., Anaheim, Calif., has purchased the Du Mont Laboratories mobile two-way radio communications business from Fairchild Camera and Instrument Corp. The business will be operated as a division of Gonset, Inc., a subsidiary of Ling Altec. The acquisition included exclusive right to the registered trademark name "Du Mont." . . . *Whittaker Corp., Los Angeles, has acquired the facilities and specialized tooling of Titanium Forming Div. of Basic Industries, Inc. The operation will become the Advanced Metals Technology Div. of Whittaker's Materials and Structures Group.* . . . Fulton Industries, Inc., Atlanta, Ga., has purchased the assets and business of Globe Imperial Co., Rockford, Ill., from Harsco Corp., Harrisburg, Pa. Globe is in the industrial plastics field. It will be operated as a division of Precision Castings Co., Cleveland, a Fulton subsidiary.

International

Motorola Semiconductor Products, Inc., Phoenix, Ariz., has opened a European service center in Geneva, Switzerland. Joseph A. Gentile has been named manager. . . . *Kuba, Tonmoebel & Apparatbau, Wolfenbuettel, West Germany, has said that it is discussing "some sort" of technical collaboration with General Electric Co. The statement followed unconfirmed reports that GE was negotiating to acquire a large interest in the firm, which manufactures radios and television sets.*

In the Courts

Bourns, Inc., Riverside, Calif., and Spectrol Electronics Corp., San Gabriel, Calif., have announced out-of-court settlement of two Federal District Court actions involving patent infringement complaints. Under the agreement, three Bourns patents were found to be valid and infringed. A license to manufacture potentiometers under the patents in litigation is to be granted Spectrol by Bourns, with patent royalty provisions.

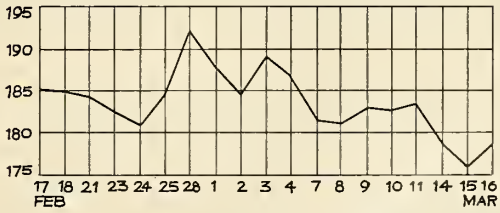
New Activities

Beckman Instruments, Inc., Fullerton, Calif., has established an Electronic Instruments Div., combining the firm's Berkeley Div. at Richmond, Calif., and Offner Operations at Schiller Park, Ill. Leo M. Chattler has been named manager of the new division. . . . *Sylvania Electric Products, Inc., Mountain View, Calif., has formed five new laboratories within the Electronic Defense Laboratories. The new laboratories are advanced analysis, electronic countermeasures, applied sciences, signal intelligence and radio frequency equipment.* . . . Computer Sciences Corp., El Segundo, Calif., has formed a Systems Programming Div. Ralph W. Pearson will head the division's business development program. He will be responsible for drawing up and implementing a plan to develop new business with computer manufacturers and government agencies. . . . *CBS Laboratories, Stamford, Conn., has expanded its electron tube department to include solid-state devices and sensor subsystems. The department will be known as the electron physics department.* . . . Data Systems Div. of Litton Industries has renamed its Information Sciences Laboratory at Waltham, Mass., the Advanced Navy Systems Laboratory. The change was made "to better describe the functions and responsibilities of the laboratory," a company spokesman said.

Industry Facilities

North American Aviation, Inc.'s Space and Information Systems Div., Downey, Calif., has announced plans to construct a $30-million, seven-building aerospace complex at Seal Beach. The complex will house management, engineering and light manufacturing activities for the *Saturn II* launch vehicle. A portion of the facility is expected to be in operation by the end of this year. . . . *Motorola, Inc., will construct a 674,000-sq.-ft. plant in Schaumburg, Ill. The facility will be used by the company's communications division.* . . . Electrikon Co., Sarasota, Fla., has leased an additional plant facility to complement its present research and engineering activities. The firm specializes in production of electro-optical systems and subsystems. . . . *Dikewood Corp., Albuquerque, N.M., has moved to a 12,000-sq.-ft. facility in the University Research Park. Dikewood is a group of systems analysts and consulting scientists.*

Missile/Space Stock Index



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Port Hueneme, California 93041 / Department 011-MR-2

contracts

AIR FORCE

$11,015,218—**United Aircraft Corp.**, Redwood City, Calif., for ordnance items.

$2,830,000—**North American Aviation, Inc.**, Rocketdyne Div., Canoga Park, Calif., for investigation of critical items for the aerospike nozzle concept.

$2,331,218—**Kollsman Instrument Co.**, Elmhurst, N.Y., for mapping and survey equipment.

$1,438,091—**Cornell University**, Ithaca, N.Y., for continuation of research in ionospheric physics.

$675,000—**Whittaker Corp.**, Los Angeles, to continue development of preimpregnated boron tape and fabrication of test specimens leading to high-performance aerospace structural components.

$298,077—**Isotopes, Inc.**, Westwood, N.J., for research on Project Vela cloud gap.

$148,319—**Texaco, Inc.**, New York City, for chemical research for advanced storable liquid oxidizers.

$144,973—**Aerojet-General Corp.**, Liquid Rocket Operation, Sacramento, Calif., for engineering services in support of the *Titan II* propulsion program.

ARMY

$5,230,320—**Bermite Powder Co.**, Saugus, Calif., to produce detonating fuzes.

$342,000—**Thiokol Chemical Corp.**, Bristol, Pa., for work on propulsion units.

$278,250—**General Electric Co.**, Schenectady, N.Y., for repair/overhaul, including modification, of unserviceable *Nike-Hercules* guided missile system klystron tubes.

NAVY

$37,853,100—**General Electric Co.**, Schenectady, N.Y., to manufacture reactor plant components for nuclear-powered vessels.

$8,740,999—**Sparton Corp.**, Jackson, Mich., to make sonobuoys.

$7,964,348—**Bermite Powder Co.**, Saugus, Calif., to make ignitors for 2.75-in. rockets.

$2,102,061—**Avco Corp.**, Richmond, Ind., fixed-price contract for *Polaris* missile components.

$2,000,000—**Genge Industries**, Glendale, Calif., to provide technical support services to the Ship Missile Station, for 3 years.

NASA

$3,000,000—**General Electric Co.**, Missiles and Space Div., Philadelphia, to build a 13-ft. conical spacecraft to be used in a flight-test to measure the heating rate of an object re-entering the Earth's atmosphere at near-orbital velocity.

$2,659,000—**Gulton Industries, Inc.**, Albuquerque, N.M., from Kennedy Space Center for data transmission systems.

$925,000—**Straza Industries**, El Cajon, Calif., to install ground support propellant supply lines at Cape Kennedy for the *Saturn V* space vehicle.

$312,532—**Radio Corp. of America**, Astro-Electronics Div., Princeton, N.J., increase in contract for the *Tiros Operational Satellite* program.

$301,670—**Lear Siegler, Inc.**, Electronic Instrumentation Div., Anaheim, Calif., from Goddard Space Flight Center for data collection and recording system for the launch phase simulator, including installation and checkout at Goddard.

$208,139—**Lockheed Aircraft Corp.**, Missiles and Space Co., Sunnyvale, Calif., from Lewis Research Center for liquid propellant thermal-conditioning system.

$192,000—**Washington Technological Associates, Inc.**, Rockville, Md., for further development of an advanced startracker.

$150,000—**General Electric Co.**, Space Technology Center, Philadelphia, from Western Operations Office for study of static and dynamic seals for liquid rocket engines.

COMMUNICATIONS SATELLITE CORP.

$265,566—**Radio Corp. of America**, Camden, N.J., **Page Communications Engineers, Inc.**, Washington, D.C., and **Hughes Aircraft Co.**, Fullerton, Calif., three separate study contracts for research into advanced equipment for Earth stations.

INDUSTRY

$1,300,000—**Trans-Sonics, Inc.**, Burlington, Mass., from **Grumman Aircraft Engineering Corp.**, Bethpage, N.Y., to provide the propellant quantity gaging section for the Lunar Excursion Module.

$728,000—**Electro-Optical Systems, Inc.**, Pasadena, Calif., from **Grumman Aircraft Engineering Corp.**, Bethpage, N.Y., to design, develop, qualify and deliver water quantity measuring devices for the Lunar Excursion Module.

$500,000—**ELTRA Corp.**, C&D Batteries Div., Conshohocken, Pa., from **Boeing Co.**, Seattle, Wash., for batteries for the *Minuteman* missile program.

$310,000—**Saginaw Producers Corp.**, Saginaw, Mich., from **Boeing Co.**, Seattle, Wash., for electro-mechanical actuators for use in the advanced *Minuteman II*.

MISCELLANEOUS

International Telephone and Telegraph Corp., ITT Federal Labs., Nutley, N.J., from **Compania Telefonica Nacional de Espana**, the national telephone company of Spain and contractor to NASA, to establish a ground terminal complex on Grand Canary Island in support of the *Apollo* program, with two terminals to be built. Amount not disclosed.

POLARIS: Ten Years "On Target"

The Navy-Industry team that created Polaris has compiled an impressive record since the program started in mid-1955. The fact that this powerful, worldwide deterrent weapon system has been "on-target" in meeting all requirements since the start is due in no small measure to the high quality of the program's management, at every level. As the Navigation Subsystem Contractor, Sperry's responsibility has been to provide perfect knowledge of sub location at launch, a necessity for a missile bull's-eye on the target. This requires a highly reliable navigation subsystem that delivers precise "on-target" performance while operating continuously, year after year. This job requires navigation expertise combined with day-in day-out ability to produce. Sperry is pleased to report to date: Polaris navigation subsystem performance has always met or exceeded specifications. Sperry-Polaris continues on target!

Sperry Polaris, Sperry Gyroscope Company, Syosset, New York

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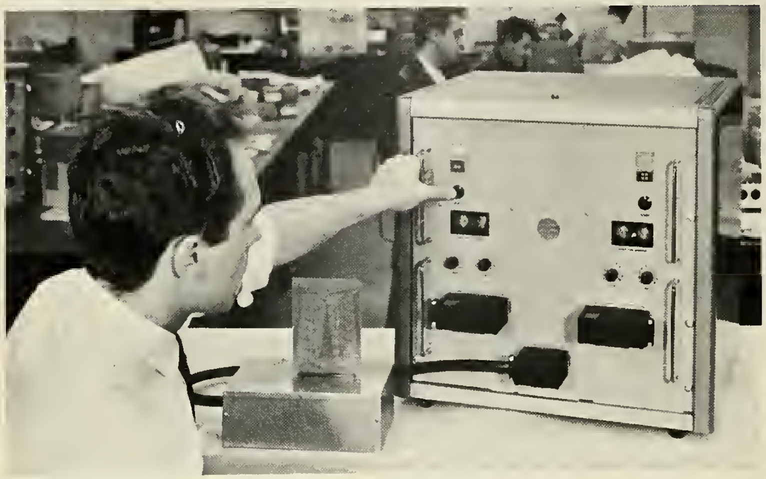

New Product of the Week: Automatic Circuit Tester

An automatic printed circuit tester for verifying compact printed assemblies on a go/no-go basis has been announced by Automation Dynamics Corp.

Model QC 400 is capable of performing analysis for continuity resistance, shorts and open circuit at a rate of five circuits per second. Each circuit point is checked to all other points individually to avoid multipath errors. Numerical readouts display pin numbers of any faulty circuits.

Programming for different circuit boards to be tested is done by wiring connectors which are plugged into the panel. Modular design permits change of test-range limits and expansion of the number of test points.

Circle No. 151 on Subscriber Service Card

Creep Testing Furnace

A high-vacuum, high-temperature creep testing furnace with maximum temperature of 3,000°C has been developed by Marshall Products, a subsidiary of National Research Corp.

Ultimate vacuum capability is 10^{-9} torr, which can be reached without bakeout. The furnace will reach 1×10^{-7} torr at 2,200°C within 2½ hours of initial pump-down.

Heavy tungsten pull rod grips are supplied for flat specimen creep testing at temperatures up to 3,000°C.

Circle No. 152 on Subscriber Service Card

Radiation Monitor

A radiation contamination monitor that permits simultaneous but separate monitoring of alpha and beta/gamma radiation is announced by EMI Electronics Ltd.

The PCM3 monitor uses a dual phosphor technique with a special transistor discriminator-trigger and gating circuits. It may be used with suitable alpha, beta, gamma and X-ray probes. Low-energy beta rays can be detected by using different types of scintillation and Geiger probes.

Visual indication of radiation level is given by a 5-in.-long scale meter. Aural indication is by an internal loudspeaker which produces separate and distinctive tones for alpha and beta/gamma radiation.

Circle No. 153 on Subscriber Service Card

Copper Heat Transfer

Astro Met Associates, Inc., has introduced a foamed open cell copper, AmPorCop Type 200.

The material produces high surface area and random structure which increases convective heat transfer rates by factors of 2 to 10 times over finned systems. This results in the cellular structure by producing turbulent flow which interrupts stagnation layers that generally occur in finned systems.

The copper is said to offer considerable size and weight reduction as well as improved heat transfer efficiences in various aerospace and aircraft heat exchangers in temperature ranges from near absolute zero to above 1,000°F.

It is available in pore sizes from about 200 to 2,000 microns (or 8 to 80 mils) and ranges from 4 to 15% of theoretical density (or pore volumes from 96 to 85% of total bulk volume) in block sizes up to 1 x 5 x 5 in. Joining techniques include brazing and diffusion bonding. Simple shapes can be prepared by band saw cutting and pressing to dimensions. More exact dimensions can be prepared by machining organically filled blanks, and subsequently removing the filler.

Circle No. 154 on Subscriber Service Card

Aerial Photography System

A system for aerial color photography, designed to broaden the uses of pictures taken from the air and provide more information from aerial photographs, has been announced by Eastman Kodak Co.

The Aero-Neg Color System offers a wide selection of possible printing and information techniques, making more information available by viewing and reading color prints or transparencies, developers say.

Greater flexibility in exposure, handling, and subsequent laboratory manipulation is also claimed by the firm. Color or black-and-white paper prints, diapositive plates, or color film transparencies may be obtained from a single camera negative.

The system uses standard photographic materials and is compatible with processing and printing equipment found in aerial photo laboratories.

Circle No. 155 on Subscriber Service Card

Power Amplifier

A series of low-noise, silicon solid-state wideband power amplifiers has been announced by Instruments for Industry, Inc.

Model 2100 provides a minimum of 1 watt CW into 50 ohms over 10 KHz to 100 MHz without tuning. Power gain of the unit is 50 db minimum with frequency response of 1 db at full-power output. Input impedance is 50 ohms nominal.

Circle No. 156 on Subscriber Service Card

Vector Voltmeter

Hewlett-Packard has announced a vector voltmeter that is a dual-channel wideband rf millivoltmeter and phase meter.

Model 8405A has a frequency range of 1 MHz to 1 GHz, with maximum

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sensitivity of 100 mv full scale, and ±180° phase measurement range with resolution to 0.1°.

The instrument directly reads voltage with one of two high-impedance probes. With a second, it reads phase angle relative to the first probe. The second probe and its meter may be switched to read voltage, giving simultaneous reading of gain between points.

Tuned bandwidth over the entire frequency range is 1 KHz. Maximum sensitivity of either channel is 100 mv full scale, with 10v maximum input.

Circle No. 157 on Subscriber Service Card

General-Purpose Centrifuge

A general-purpose centrifuge with maximum g-range of 0 to 200 g's has been announced by the Gyrex Corp.

Model 570 can be used for precision calibrating and environmental testing of components to simulated g-forces. Maximum centrifugal capacity is 5,000 g-pounds.

The centrifuge has a servo-controlled magnetic coupling drive system with 1-hp motor. Boom rotation speed is infinitely variable from 30 to 650 rpm, with basic accuracy of 0.05% drift per minute above 1 g.

Circle No. 158 on Subscriber Service Card

Monolithic Commutator

A monolithic multi-channel commutator for use in systems where low on-resistance and low channel leakage is required has been developed by Fairchild Semiconductor.

The Model UM3700 offers on-resistance of less than 200 ohms and channel leakage of less than one nanoamp per channel. Using MOS field effect transistors as active resistors, the device has all-channel blanking capability for four-channel operation.

Input analog signal voltage is ±10v, and output capacitance is 40 picofarads. Channel turn-on time is 500 nanoseconds; turn-off time is 2 microseconds.

Circle No. 159 on Subscriber Service Card

Reflex Klystron Oscillator

A reflex klystron oscillator designed as a pump tube for parametric amplifiers and masers has been announced by Varian Associates.

Model VA-294 will deliver at least 100 milliwatts into a matched load over the entire tuning range. Tubes are available at any frequency between 26.5 and 40 GHz, and have a mechanical tuning range of at least 1,000 MHz.

Heater voltage is 6.3 ±0.6v with typical heater current of 1.33 amps.

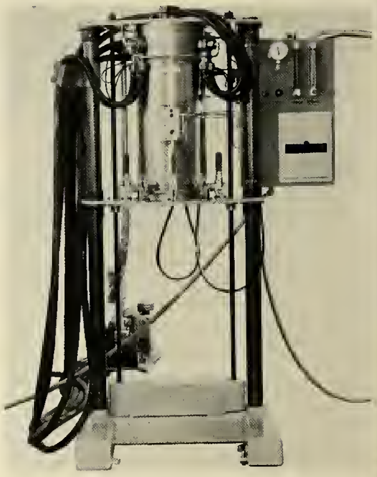
Circle No. 160 on Subscriber Service Card

Graphite Furnace

A pilot process furnace capable of operating with hydrogen at temperatures up to 2,500°C has been introduced by Astro Industries, Inc.

The Model 70-100 graphite furnace is designed for processing with inert gas, hydrogen or moderate vacuum environments. It incorporates an automatic safety purge system for hydrogen operation.

The cylindrical hot zone is 7 in. in diameter and 12 in. long. Design permits top, bottom or straight-through access. The hearth is electromechanically driven in vertical operation. Power supply is three-phase, SCR-controlled, with continuous manual adjustment or optional plug-in proportional-type automatic temperature controller.



The automatic purge system includes pressure relief, burst diaphragm, vacuum pump, pilot burner and solenoid-operated valves.

Circle No. 161 on Subscriber Service Card

Tracking Telescope

Photronics Corp. has developed a bi-power (20X-40X) tracking telescope which incorporates a solid-state electronic acquisition aid.

The system consists of CRT and associated circuitry, mounted on the telescope and connected by cable to the power supply box. Azimuth and elevation error voltages from radar are fed into amplifiers which deflect the spot within the limits of the inscribed square on the one-inch CRT.

The telescope gives clear aperture of object of 100m. True field of view is 3° and 1½°, with apparent field of view of 60°. Exit pupil is 5 mm and 2.5 mm and eye relief 25 mm. The adjustable eyepiece focus is ±5 diopters; resolving power is 3 sec. arc.

Circle No. 162 on Subscriber Service Card

Do-It-Yourself Converter

A do-it-yourself, 10-bit, 8-kc analog-to-digital converter has been announced by Raytheon Computer.

The kit includes 13 digital modules needed to make up comparator, control, reference and register sections of the converter, plus documentation covering the recommended module layout, block diagram and wiring list.

The converter uses the successive approximation conversion technique to convert analog signals to 10-bit resolution at speeds up to 8 kc and accuracy of 0.1 to 0.5%. Inputs are ±10v, input impedance is 20 ohms, and output is —10v nominal (true) and 0v (false).

Circle No. 163 on Subscriber Service Card

Operational Amplifier

Analog Devices has announced a series of differential operational amplifiers for use as preamplifiers in precision servos and low-frequency applications where high d-c gain and low drift stability are required.

Series 103 Models A, B, and C have 20 μv/°, 10 μv/°, and 5 μv/°C voltage drift, respectively. Current drift of 0.2 na/°C and supply voltage drift of 15 μv/°C are the same for all three models.

Parameters for the 103 Series include 100-db dc gain, 0.13-v/μsec. slewing rate, 5-millisec. overload recovery time, 4-megohm differential and 400-megohm common-mode input impedance, 10-v maximum common-mode input voltage, 20,000 CMRR and 4 μv noise in the dc to 50-kc band.

Circle No. 164 on Subscriber Service Card

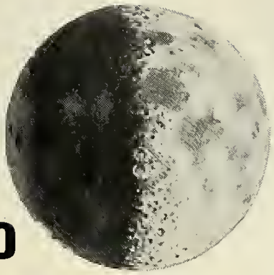
Traveling Wave Tube

A traveling wave tube which can increase power output of microwave systems by an order of magnitude has been introduced by the EIMAC Div. of Varian Associates.

The X-1205 TWT is transparent to microwave signals under beam-off conditions so that high-power pulsed or CW signals may be sent through it with a maximum insertion loss of 1 to 2 db. In the beam-on configuration, the tube becomes a 10-db power amplifier and provides an order of magnitude increase in signal level.

Operating characteristics of the unit include 2.8 to 5.2-gc frequency range; 1.5-kw minimum peak power output; 2% duty cycle; 10-db gain, and 25% efficiency. The tube is lightweight and miniaturized for operation under severe airborne and missile environments, the firm says.

Circle No. 165 on Subscriber Service Card



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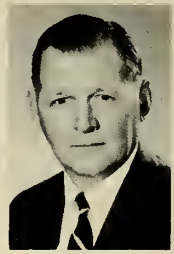
HOLSCHUH

R. D. Chandler, Jr.: Named a vice president of the Lockheed Electronics Co. He is general manager of the Houston Aerospace Systems Div. at the Manned Spacecraft Center.

Frank R. Meshowski: Appointed vice president, sales, of the components group at Gulton Industries. **Bernard B. Herman** was named vice president of operations for the company's alkaline battery division.

Dr. Thomas C. Searle: Appointed manager of work for the Communication Satellite Corp. program at Sylvania Electronic Systems, a division of Sylvania Electric Products, Inc.

J. N. Veale: Appointed executive vice president of Technical Operations Research's System Sciences Div. He was formerly vice president for marketing for Univac Div. of the Sperry Rand Corp.

Dan Goor: Appointed assistant to the president of Andersen Laboratories, Inc. His responsibilities will include special technical assignments, general management and development of the company's new products.

Carl G. Holschuh: Named group vice president of the Marine Systems Div., a new group of General Dynamics Corp. He was executive vice president of Sperry Rand Corp. and joined the company last year.

Brig. Gen. John L. McCoy: Nominated by President Johnson for the temporary rank of major general. He is commander, Ballistic Systems Div., Norton AFB, Calif., and is deputy commander for the *Minuteman* program.

Dr. Joseph Neustein: Elected a vice president of Electro-Optical Systems, Inc., and named associate manager of research and engineering. He will be responsible for the engineering programs in all four EOS technical groups.

Sidney Moskowitz: Appointed vice president and general manager of Electronic Research Associates, Inc. He has published a book, *Pulse Techniques*, and has two U.S. patents.

James S. Martin: Named president of Walter C. McCrone Associates, Inc. He replaces Walter C. McCrone, the founder of the firm, who will continue as chairman of the board and senior research associate.

W. Clark Moore: Named vice president of Insulating Fabricators Southern Div., Inc. He was also named general manager of Insulfab Container Corp.

Thomas C. Drees: Elected executive vice president of Spaulding Fibre Co., Inc. He recently returned from England, where he was chairman and managing director of the company's foreign subsidiaries.

John A. Ammerman: Named vice president of operations at Latronics Corp. **J. S. Murray** has been elected vice president of engineering for all ceramic and glass-to-metal products.

George L. Freeman: Elected vice president and treasurer of the G. T. Schjeldahl Co. He was formerly president of the Photo Color Process Corp.

James H. Green: Appointed vice president and senior director of Atlantic operations at Page Communications Engineers, Inc. He is a senior member of the IEEE and holds basic patents in the field of correlation communications.

Dr. Harper Q. North: Received the Electronic Industries Association's Medal of Honor. He is president of EIA and vice president of TRW, Inc.

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Fourth International Aerospace Instrumentation Symposium, sponsored by the Instrument Society of America, Cranfield, England, March 21-24.

International Convention, sponsored by the Institute of Electrical and Electronics Engineers, Coliseum & New York Hilton Hotel, New York City, March 21-25.

Second Annual Solar Energy Society Conference, Somerset Hotel, Boston, March 21-23.

American Chemical Society 151st National Meeting, Pittsburgh, March 22-31.

Conference on Neutron Cross-Section Technology, sponsored by the American Physical Society, Atomic Energy Commission, National Bureau of Standards and American Nuclear Society, Shoreham Hotel, Washington, D.C., March 22-24.

1966 National Convention, Air Force Assn., Dallas, Tex., March 22-25.

Conference on Modern Methods of Weather Forecasting & Analysis, sponsored by the American Meteorological Society, University of Chicago, Chicago, March 24-25.

"Photo-Imaging Materials for Science and Industry," sponsored by the Society of Photographic Scientists and Engineers, Hotel Plaza, New York City, March 24-25.

Human Factors & Bioengineering Conference, sponsored by the American Society of Mechanical Engineers, International Inn, Washington, D.C., March 28-29.

Stepping Stones To Mars Meeting, sponsored by the American Institute of Aeronautics and Astronautics, American Astronautical Society, Baltimore, March 28-30.

Sixth National Conference in Applied Meteorology, sponsored by the American Meteorological Society, American Institute of Aeronautics and Astronautics, Los Angeles, March 29-31.

Seventh Symposium on Engineering Aspects of Magnetohydrodynamics, sponsored by the American Society of Mechanical Engineers, Institute of Electrical and Electronics Engineers, American Institute of Aeronautics and Astronautics, and Princeton University, Princeton University, Princeton, N.J., March 30-April 1.

APRIL

Rubber & Plastics Industries Conference, sponsored by the Institute of Electrical and Electronics Engineers, Sheraton-Mayflower Hotel, Akron, Ohio, April 4-5.

Conference on Exobiology, sponsored by the National Aeronautics and Space Administration and University of California Extension, Ames Research Center, Moffett Field, Calif., April 4-6.

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The New Space Poll

FOR THE PAST THREE YEARS, Thiokol Chemical Corp. has sponsored a semi-annual Trendex poll on public opinion of the nation's space program. Results of the latest poll, taken in January of this year and just released, show that support for the *Apollo* lunar-landing program has achieved a new high.

Some 77% of those interviewed now favor the program, as against only 20% opposed to it. This is a dramatic gain from 1963, when only 59% were in favor of the lunar landing and 39% were opposed.

It is worthwhile to ask what brought about this increase in public support.

It is almost certain that the public's greater knowledge of the national space program accounts for the stronger support for it today. It has long been our view that a well-informed public is one of the greatest assets of this nation.

Immanuel Kant once wrote: "That all our knowledge begins with experience there can be no doubt."

There also can be no doubt that the public's greater experience with the space program is due directly to personal involvement through the national communications media.

These media have done an outstanding job, not only of covering the dramatic launches in the manned space program, but also of explaining the purpose and objectives of the space effort. The television networks have devoted long hours to the space flights. Knowledgeable commentators such as Jules Bergman of ABC, Roy Neal of NBC and Walter Cronkite of CBS have filled in quiet moments in those hours with intelligent, erudite discussions of obscure technical points and of the goals of the National Aeronautics and Space Administration.

Many of the nation's newspapers have assigned top-notch reporters to space coverage, men such as Marvin Miles of the *Los Angeles Times* and William Hines of the Washington *Evening Star,* to bring their readers detailed analysis and informed criticism of the space program.

The weekly news magazines have covered space with enthusiasm, if not always with accuracy. Whatever one may think of *LIFE* magazine's exclusive contract with the astronauts, there is little doubt the personal accounts by the astronauts have wide readership. *Look* and even the ladies' magazines have contributed further human-interest material. *Fortune's* lengthy, informative articles have reached the top level of the business community. There is no praise too high for the beautifully illustrated reports in *National Geographic.*

There are, of course, other factors involved. One is the willingness of the astronauts themselves to devote time to the cause. John Glenn, for one, has been tireless in his work with youth groups. A number of astronauts have undertaken trips both at home and abroad in behalf of the space program.

There also is the effective public relations work of such Government officials as NASA Administrator James Webb, Dr. George Mueller and Dr. Ed Welsh, who have consumed uncounted plates of creamed chicken and peas in the line of duty prior to explaining the objectives of the space program to public groups.

All of this has greatly increased public knowledge of the space effort, a fact statistically reflected in the Thiokol poll.

The poll, however, also raises several questions. It is interesting to note the response to queries concerning the military space program. This question was asked: In the long run, do you think exploration of space will be of greater importance to the United States because of—defense and security, scientific and non-military benefit, or opportunities for economic growth and employment? (Categories to which there was a minor response have been eliminated.)

IN THE FOUR CITIES in which the latest poll was conducted—Cincinnati, Syracuse, Pasadena and Des Moines—the public appears to be far ahead of the Administration in its assessment of the importance of military space. The response was: defense and security, 38%; scientific and non-military benefit, 35%; and opportunities for economic growth and employment, 18%.

This public concern with the importance of the military space program certainly has not been reflected in the Dept. of Defense budget. It might be well for the Administration to consider what its neglect of this vital area might mean if an informed Republican Party should choose to make it an election issue this year.

The low percentage racked up in regard to opportunities for economic growth suggests that one important aspect of the space program, perhaps its most important aspect, has not been well sold to the public. As Dr. Welsh, executive secretary of the National Aeronautics and Space Council, pointed out in a speech just last week, the benefits from the space program will be so apparent within 15 years that no one will question expenditures in this field.

The poll reflected a majority feeling that enough is being spent today on the nation's space exploration program. But when respondents were asked whether any possible increases should go to the military or civilian program, there was a curious divergence of opinion. Pasadena, for example, came out 50% to 43% in favor of the military, while Des Moines voted in favor of the scientific effort, 52% to 38%. Whether this reflects a greater knowledge in more space-oriented Pasadena or whether it reflects the traditional reaction to a military threat of a coastal city in comparison with a Midwestern city is difficult to say.

Overall, we are encouraged by the public enlightenment shown in regard to both the military and civilian space programs. We hope this worthwhile poll will continue to keep us informed on these significant trends.

William J. Coughlin

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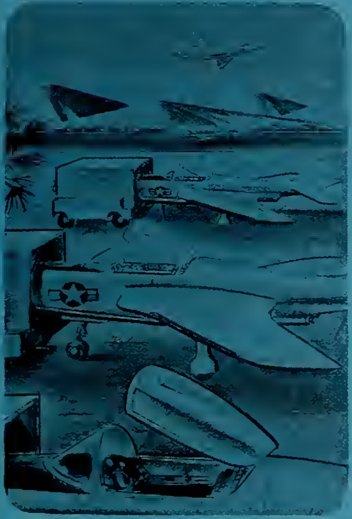

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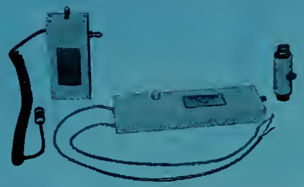

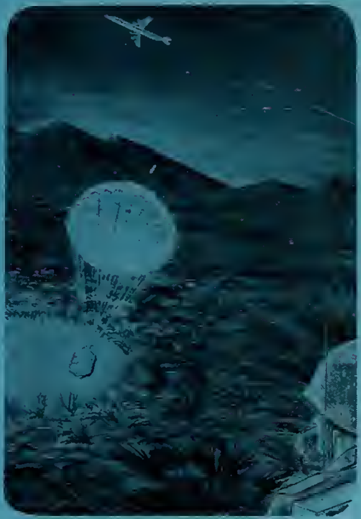

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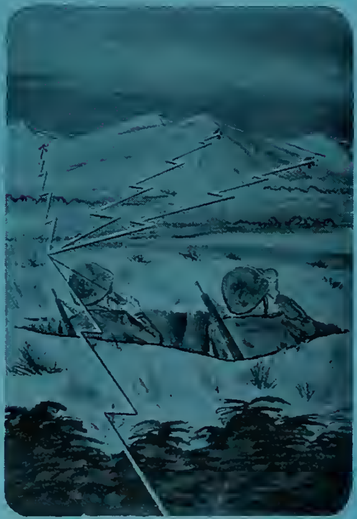

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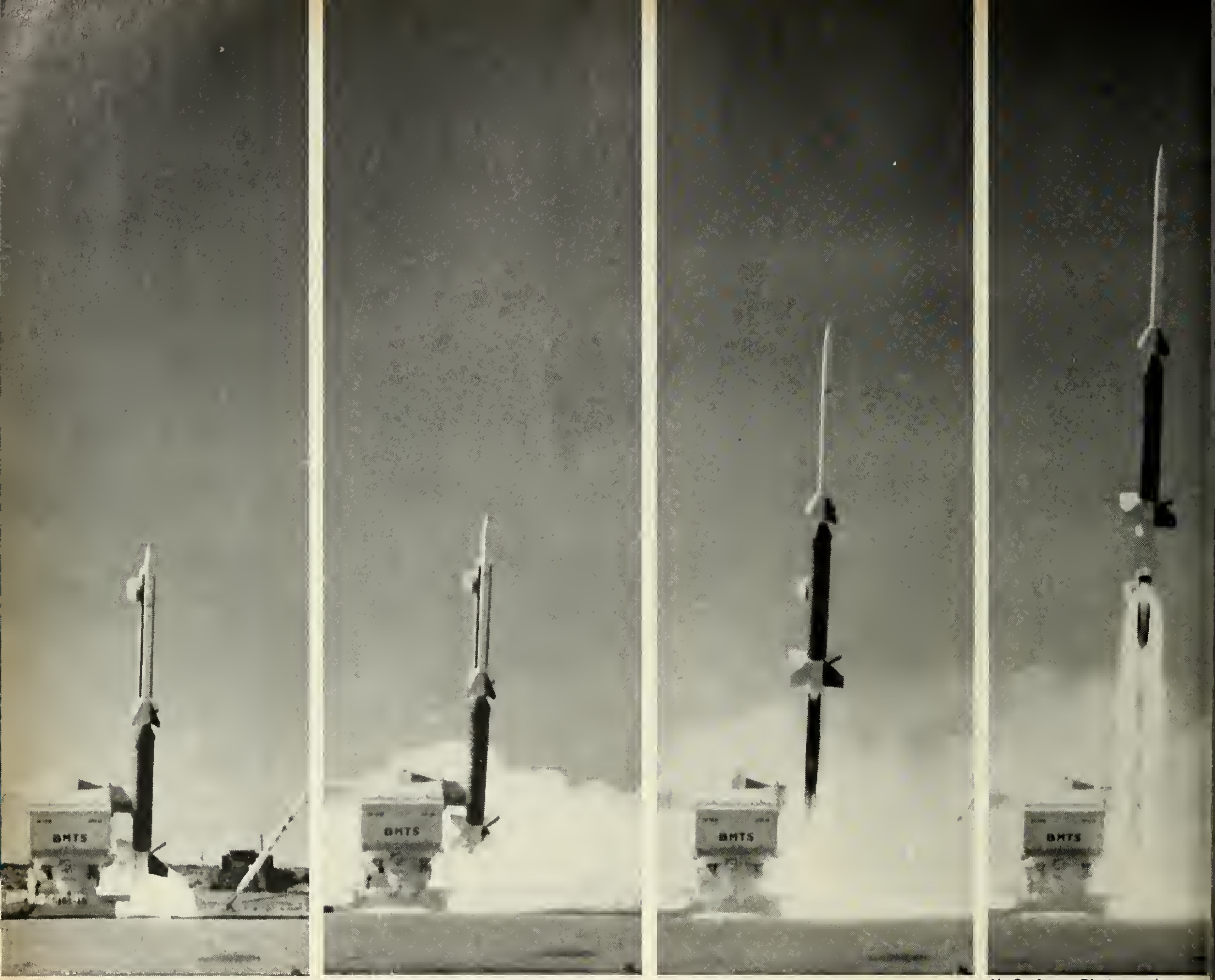

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Volume 18, Number 13 March 28, 1966

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THE COVER

Men of the U.S. Army's First Infantry Div. move through swamps just 30 miles north of Saigon in an area long controlled by the Viet Cong. This Fifth Annual DOD issue of M/R covers the problems encountered in limited warfare and the efforts under way to solve those problems.

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Compiled under the direction of Military Editor Michael Getler

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MEMO FROM THE PUBLISHER

COUGHLIN GETLER

THE MEN ABOVE are among the reasons why this special Dept. of Defense issue on the lessons of Vietnam is the frankest appraisal to date of the Southeast Asia conflict.

The photographs show Editor William J. Coughlin in an F-100F just after return from a combat strike mission in close support of ground troops of the 101st Airborne and Military Affairs Editor Michael Getler suited up for a strike with the F-5's of the Skoshi Tigers.

We could equally well have shown them aboard the carrier Enterprise, riding the helicopters of the Army's First Cavalry Division or on night patrol in the South China Sea aboard a Navy boat searching for Viet Cong and contraband.

They are experienced hands at this sort of thing. This is Coughlin's fourth war. A P-38 pilot in World War II, he has covered Korea, Suez and now Vietnam. Getler is a former naval aviator.

With this background and long acquaintance with the advanced-technology potential of the missile/space field, they were in a unique position to evaluate what they saw and heard throughout South Vietnam. Talking to admirals and generals, colonels and commanders, sergeants and bosuns, they elicited honest appraisals of major problems confronting our forces in the combat zone. Their Report from Vietnam beginning on p. 43 should be must reading for every executive and engineer in the industry.

While the Editor and Military Affairs Editor were in Vietnam, other members of the MISSILES AND ROCKETS editorial staff were surveying the potential of the U.S. industry and military in applying advanced technology to limited warfare. Their look at possible answers to the problems raised in the Report from Vietnam is Part II of this Fifth Annual DOD issue.

The Dept. of Defense and the military services have set up a number of new management procedures to deal with research and development for the conflict in Southeast Asia. This management structure and the limited-warfare budget are examined in Part III.

This is not just a survey of operations in Vietnam; it is an in-depth analysis of the problems encountered there and the efforts to meet them. It is part of a continuing look at Vietnam which began three years ago when this magazine and its sister publication, *American Aviation*, were the first trade journals in the field to send a correspondent into Vietnam.

It is this type of experienced reporting which has just won for M/R the American Business Publications' Neal Award, the Pulitzer Prize of business journalism, and which has pushed our circulation to an all-time high of 45,500.

We think it is the most valuable single issue for industry we have ever published. I believe you will agree.

James W. Claar
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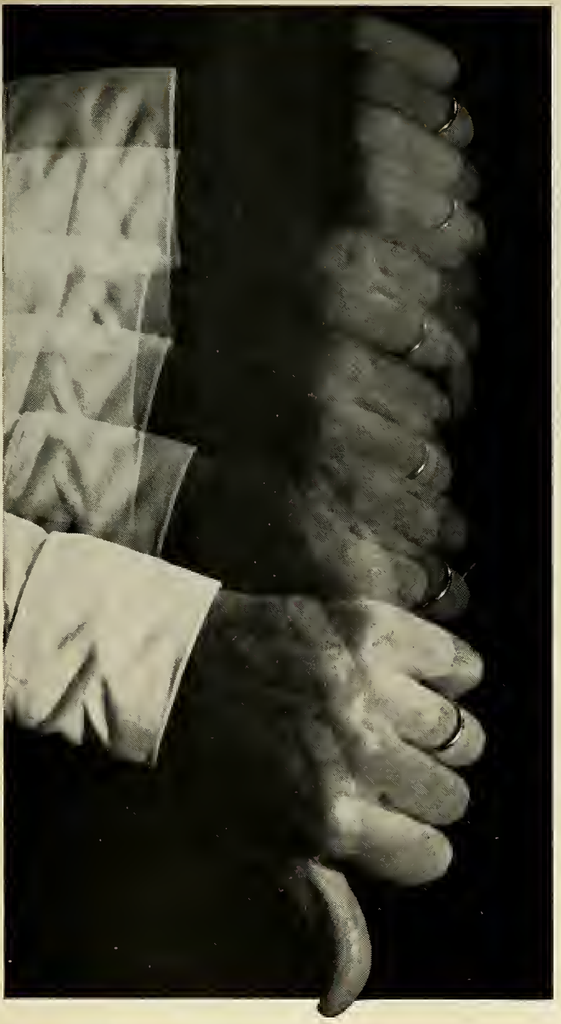

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The airplane that is made for this kind of fighting is called the F-5.
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The Countdown

WASHINGTON

Navy Selects Condor Contractor

Navy finally has selected a contractor for development of the *Condor* long-range electro-optically guided stand-off missile, sources close to the program tell COUNTDOWN. Announcement is expected within two weeks. Northrop's Norair Div. and North American Aviation's Columbus Div. hold competitive definition-phase contracts.

NASA To Award Lifting Body Study

NASA's Office of Advanced Research and Technology is expected to award a contract this week for a conceptual study of the potential and cost of developing a lifting-body re-entry vehicle. Such a follow-on to the current *M-2* and *HL-10* programs might eventually be launched on a ballistic test flight. Six firms—Grumman, Douglas, Martin, McDonnell, North American and Northrop—are competing for the contract.

Redeye Enters Final Tests

Army's *Redeye* shoulder-fired anti-aircraft missile, in development for almost seven years, will enter its final engineering evaluation tests at White Sands Missile Range, N.M., on April 1. The 28-lb., two-stage solid-propellant missile, which uses an infrared seeker, reached the conclusion of its development test program at Naval Ordnance Test Station, China Lake, Calif., in February with three successful interceptions of KD2R propeller-driven drones. Direct hits were recorded at 400, 2,500 and 4,500 ft.

NASA May Use LEM Engine for Mars

NASA now is considering use of the Lunar Excursion Module descent engine to achieve a *Voyager* soft-landing on Mars. The propulsion system for such a feat will require a thrust of over 10,000 lbs. in order to put both the spacecraft and landing capsule into Martian orbit and then land the capsule on the surface.

Where Have All the Sparrows Gone?

To Vietnam, according to sources at White Sands Missile Range. In any event, they are no longer readily available for boosting *Arcas* meteorological sounding rockets. Nor are *Sidewinders.*

Cost Holds Up SAM-D

Dept. of Defense officials say cost is the principal factor holding up Requests for Proposals on the Army's new *SAM-D* field air defense system (M/R, Jan. 3, p. 12). Officials are hopeful that a review of the cost factor will be completed in time for Army to issue RFP's within three to four weeks.

New Missile at the Same Old Stand

Army will use engine test stands originally developed for *Pershing* and *Redstone* missiles to check out propulsion units for the new *Lance* battlefield artillery missile. The stands at Army Missile Command, Redstone Arsenal, Ala., have been modified and activated ahead of schedule. This will support extended engine development on *Lance* by permitting engine qualification tests earlier in the program.

Navy Wants Sub Signatures

Do deep-diving submarines leave signatures visible from an orbiting spacecraft? The answer is of such prime interest to the Navy that some work on this may already have been done on *Gemini* flights without waiting for such an input from the *Manned Orbiting Laboratory* program. Astronauts have reported ship sightings but have said nothing publicly about sub signatures.

Air Defense F-111 Under Study

An air defense version of the F-111 is being seriously studied, according to a top Air Force official. This could develop an AF requirement for a missile similar, if not identical to, the *Phoenix* missile slated for the Navy version of the F-111.

Dual Mission Seen for DSRV

There may be more than meets the eye in the Navy's program to develop a deep-submergence rescue vehicle capable of reaching 6,000-ft. depths. While rescue of nuclear submarine crews down to crush depth of one mile is important, it may be even more important to the nation's security to determine why a *Polaris* submarine failed to return from station. If attributable to enemy action in a silent war beneath the sea, it would be a tipoff to an advance in the state of the art.

INDUSTRY

New Cameras Will Track ICBM's

Air Force Systems Command's Special Weapons Center at Kirtland AFB, N.M., has developed a new Airborne Astrographic Camera System (AACS) for photographing ICBM's over water and during re-entry. The large-aperture cameras are mounted in two C-135 jet aircraft. The units are expected to substantially improve range tracking over water and to substitute for fixed ground-based optical recording stations during bad weather. They also will make possible precise optical measurements during re-entry when the plasma sheath obscures electronic measurements.

NASA Sets Saturn V Contract

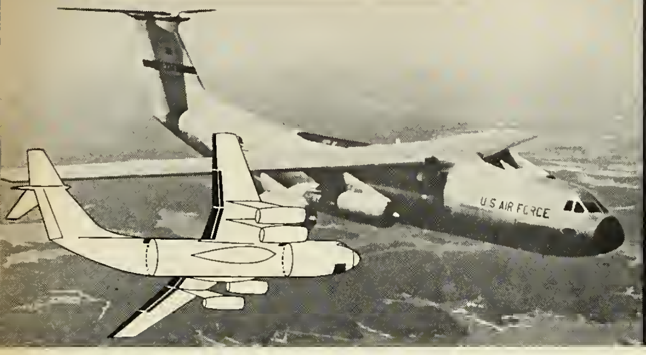
The space agency has agreed with North American Aviation and Boeing on final details of the contract for delivery of the last five *Saturn V* first stages and 15 F-1 engines. Costs are in excess of $165 million for the stages and $150 million for the engines.

INTERNATIONAL

Soviets Not Interested in Missile Freeze

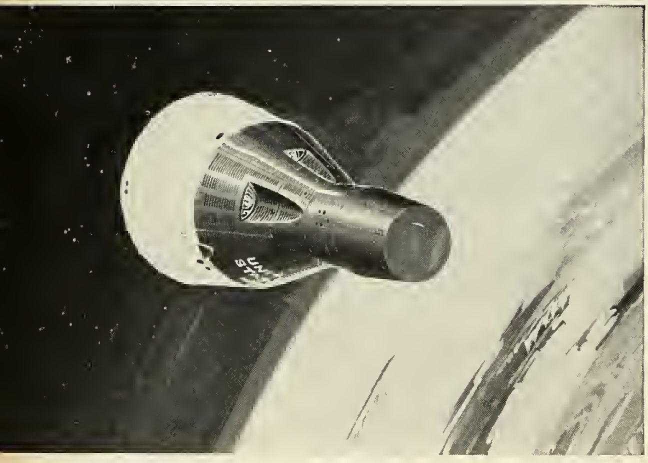
The Soviet Union has shown no interest in a U.S. proposal made in Geneva that it reconsider its rejection of President Johnson's offer of a "verified freeze" on production of missiles and other strategic vehicles for launch of nuclear bombs. The Soviet delegate to the 17-nation disarmament conference did not respond to the renewed U.S. proposal.

BEECH "IMAGINUITY" AT WORK:



For Lockheed, Beech builds several wing sections, nose landing gear doors and emergency exit doors for the huge new U. S. Air Force C-141A "StarLifter" turbofan jet transport. This massive military cargo aircraft has speeds up to 550 mph.

For McDonnell, Beech builds wing sections, flaps, ailerons, speed brakes, spoilers, landing gear doors and nose gear doors for the 1,500 mph Navy/USAF "Phantom II" jet fighter, considered one of the most versatile fighter-bomber-interceptors ever built.



For NASA's Project Gemini, Beech was chosen by McDonnell to design, develop and build the ground support equipment that supplies liquid hydrogen and liquid oxygen for the reactant supply system and the environmental control system aboard the Gemini spacecraft. Beech equipment is used at 11 vital points.

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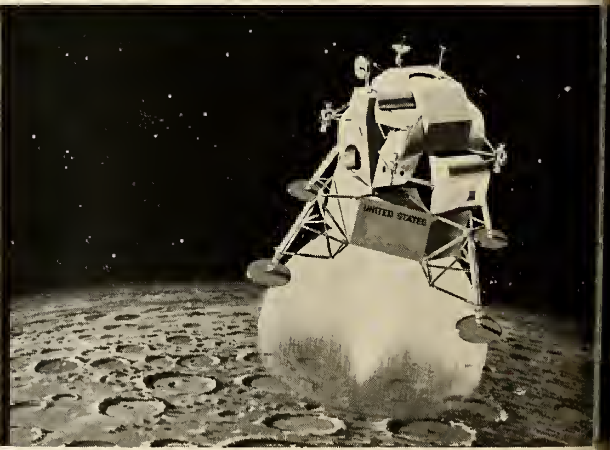
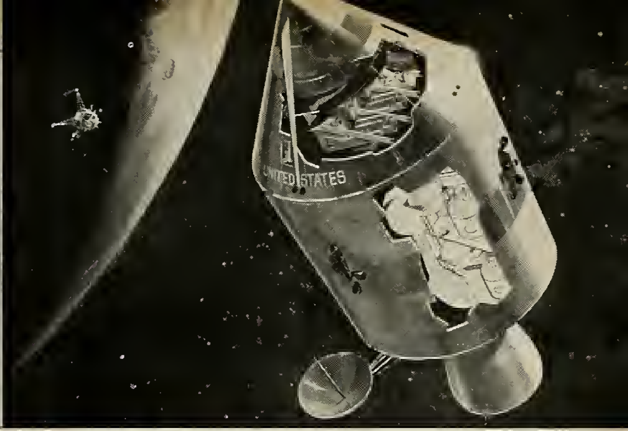
The U. S. Air Force F-105 "Thunderchief" jet fighter-bomber, which can deliver weapons at twice the speed of sound, flies on Beech-built ailerons and aft fuselage assemblies. Beech has built major components for virtually every Century-series fighter.



For the LEM, Grumman selected Beech to assure complete systems responsibility for the design, development, fabrication, and testing of equipment required for storage, transfer, and loading of liquid helium—used aboard LEM to pressurize propellant tanks to assure proper flow in weightless environment.

For Bell, Beech builds metal bonded fuselage panels which contribute to the exceptional structural strength of the U. S. Air Army HU-1D "Iroquois" jet-powered helicopter. One of the fastest and most effective rotary-winged aircraft in our military services, the "Iroquois" also has Air Force and Marine use.



Chosen by North American to develop and build the Cryogenic Storage Subsystem to supply "shirtsleeves" atmosphere to the astronauts and generate electrical power for the Apollo command module. A cryogenics pioneer, Beech has made vital contributions in weight reduction and mission duration for space vehicles.

On these pages are just a few examples of how Beech's broad range of capabilities help many of America's leading prime contractors fulfill their responsibilities for vital military and aerospace projects.

Beech's extensive experience since the early days of World War II in meeting prime contractor's requirements ...Beech's reputation as a developer of new techniques ...and Beech's extensive facilities...have earned the respect of such outstanding industry leaders as Bell, Convair, Lockheed, McDonnell, North American, Republic, and others.

In addition, Beech has the ability to assume complete systems management responsibility for a wide range of space-age projects. An example is the U. S. Navy AQM-37A missile target system—the *first* missile target system to match the performance of the fastest enemy jets. A Beech project from concept to hardware, it is also the first supersonic target system ever to be designed, developed, tested and put into production by *one* company.

Among other special advantages that make Beech a preferred choice for any type of assignment are:

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Beech "Imaginuity" in research, development and technical fabrication is already being utilized by leading prime contractors on many of today's military and aerospace projects.

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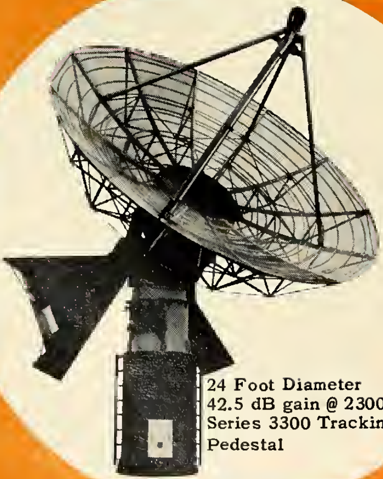

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The Missile/Space Week

Gemini-Apollo Rendezvous Studied

Manned Spacecraft Center officials are expected to propose to Headquarters that the *Gemini 12* spacecraft rendezvous with the first manned *Apollo* spacecraft.

MSC Director Robert R. Gilruth said the proposal is under active consideration at MSC. Objective of the rendezvous would be to visually inspect the exterior of the three-man *Apollo* spacecraft in orbit (M/R, March 21, p. 13).

Both flights are officially scheduled for the first quarter of 1967, but unofficially NASA hopes to launch both in November of this year.

While the plan is being pushed by MSC, it is known that the Headquarters Office of Manned Space Flight opposes it. As a result, approval at the moment is doubtful.

The planned space spectacular was revealed as the space agency announced that an electrical short caused the *Gemini 8* Orbital Attitude Maneuvering System to run wild and force an early termination of the mission March 17.

NASA officials said that there was no indication of pilot error. Instead, both Command Pilot Neil Armstrong and Pilot David R. Scott demonstrated exceptional ability in regaining control of the spacecraft.

The crew was forced to use the re-entry control system to dampen a roll rate of 360 degrees per second, which was rapidly pushing the crew to their "physiological limits."

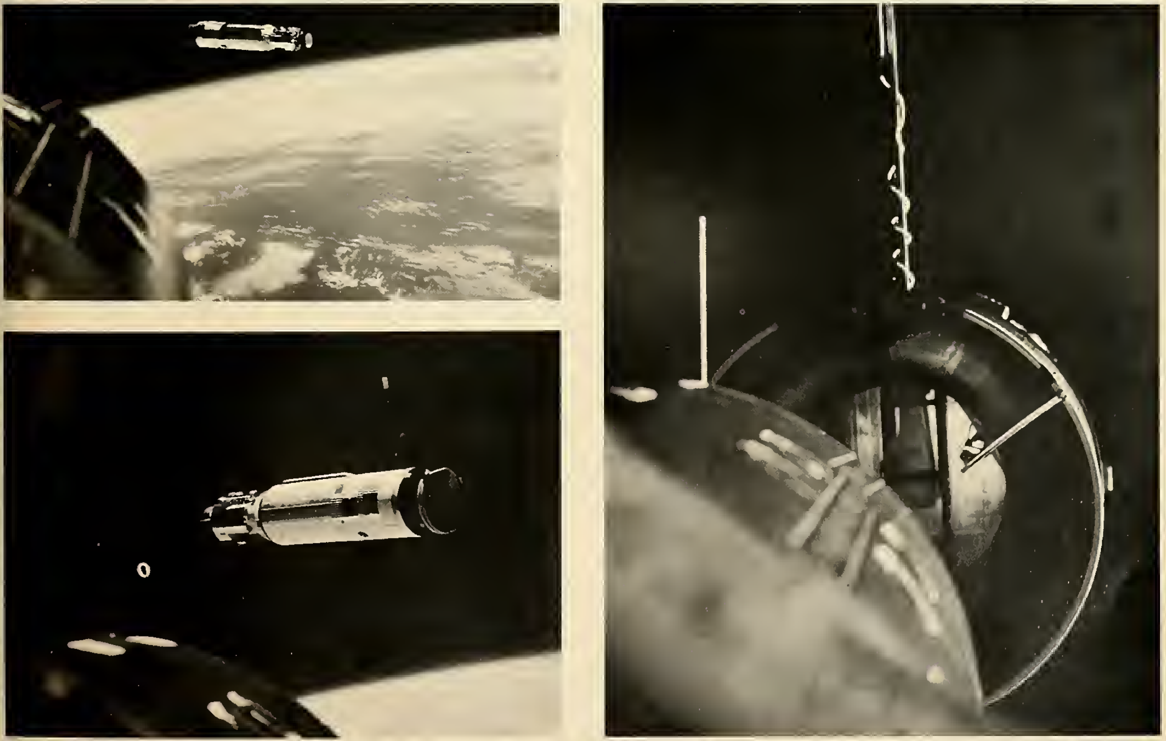
The determination that a short caused the malfunction—which occurred just after the *Gemini* docked with the *Agena*—means that there will be no delay in launching the *Gemini 9* mission, scheduled for May.

Apollo mission crew training for the first *Apollo* mission is scheduled to begin May 1. The prime crew will include Air Force Lt. Col. Virgil "Gus" Grissom, commander of the mission, Air Force Lt. Col. Edward H. White II, and Navy Lt. Roger B. Chaffee.

Backup crew for the first manned *Apollo* mission is Air Force Lt. Col. James A. McDivitt; Air Force Maj. David R. Scott; and Russell L. Schweickart, a civilian.

It is believed that McDivitt will later be assigned to the *Apollo 207* mission, which will be the first manned launch of a Lunar Excursion Module. Also expected to be named to that crew is Air Force Col. L. Gordon Cooper, who is the astronaut office expert on LEM development.

Photos made from individual frames taken from motion picture films taken by Gemini 8 Astronauts Neil Armstrong and David Scott show sequence of events just before successful docking of the spacecraft with its Agena target vehicle. This was the first docking of two objects in space. It occurred just before premature termination of the flight.



IEEE Told of Its Undersea Challenges

NEW YORK—Man's progress in deep submergence is being limited by two fundamental problems, both of which must be solved by the electronics industry—how men on the sea can communicate with men beneath the sea and how men on the sea bottom can make direct observations.

Both problems are formidable, declared J. H. Clotworthy, vice president of the Westinghouse Underseas Division, before the 1966 International Convention of the Institute of Electrical and Electronics Engineers here last week, but once the industry has met and coped with the seemingly immutable physical laws now limiting these advances "disadvantage may be turned to advantage and solutions will appear."

At present, he said, the underwater telephone range is severely limited and subject to wide performance variations, as seawater temperature varies with depth. Also, with straight acoustical systems, limited bandwidth restricts high data rates. The problem is increased because the present lack of knowledge of the medium creates doubt as to what constitutes unnecessary data. Slow acoustical transit time further complicates the problem.

The seawater attenuation and back-scattering of light greatly limits direct underwater observations. Even under ideal conditions, maximum usable distance for direct horizontal observation is about 50 ft., Clotworthy said.

DSSP needs—The immediacy of the need-to-see problem in the ocean environment was pointed up, during the two-session Undersea Technology discourse, by Joseph A. Cestone's description of the instrumentation requirements for the Navy's Deep Submergence Systems Program (DSSP) rescue and search vehicles. Major equipment needs for both submersibles, said the chief engineer of the Special Projects Office Navigation Branch, include vehicle sensors, displays and controls.

For rescue operations, he said, descent, approach, and mating with the distressed submarine are the predominant mission phases. Homing, rather than navigation, is employed and the need to see is critical, since the rescue vehicle must operate freely in the vicinity of the ocean floor and maneuver near and around obstacles.

Evasive maneuvers will be effected by thrustors rather than control surfaces, since vehicle speed will be low and the craft will be in close proximity to obstacles. For terrain-clearance control, good vertical and horizontal situation displays are mandatory. Hover control requires the ability to sense and maintain station in the presence of deep-ocean currents. For altitude control while mating with a submarine at roll and pitch angles up to 45 degrees, accurate sensing and graphic display will be needed.

Vertical and horizontal obstacle-avoidance sonars will be employed together to sense and display objects on the ocean floor. The vertical OAS will provide a 15-degree beam capable of a 4,500-ft. maximum range; the horizontal OAS will provide a 60-degree sector scan over a similar range. Both will supply inputs to separate displays showing target range and angle (HOAS, obstacle plan view; VOAS, obstacle profile).

The craft, after close approach, hovers and holds its position over the target vehicle by nulling on Doppler velocity signals. Short-range sonar is then used (in turbid water) to orient and lower the submersible onto the escape hatch of the submarine. Again, range and angle are displayed. If the water is clear, or with very close range to the distressed vehicle, a TV monitor or even viewports may be used for direct pilot observation.

The search mission, said Cestone, will require principal phases of navigation, observation, and terrain clearance. A regular search pattern will be employed, and, due to present limitations of sonic, optical, and magnetic sensors, vehicle operation will have to be near the ocean floor.

Because precise navigation of the search vehicle must be maintained, more sophisticated obstacle-avoidance techniques will have to be employed. Navigation will be geared to a number of fixed reference points, using an anchored beacon transponder network.

To test and evaluate the myriad of new sensors, displays and controls and to train DSRV crews, Trieste II will be used by the Navy, Cestone said.

Micromin sea instrumentation—". . . The oceanographer has everything to gain and nothing to lose by microelectronicizing his electronic systems," according to William Liben of the Applied Physics Laboratory, Johns Hopkins University.

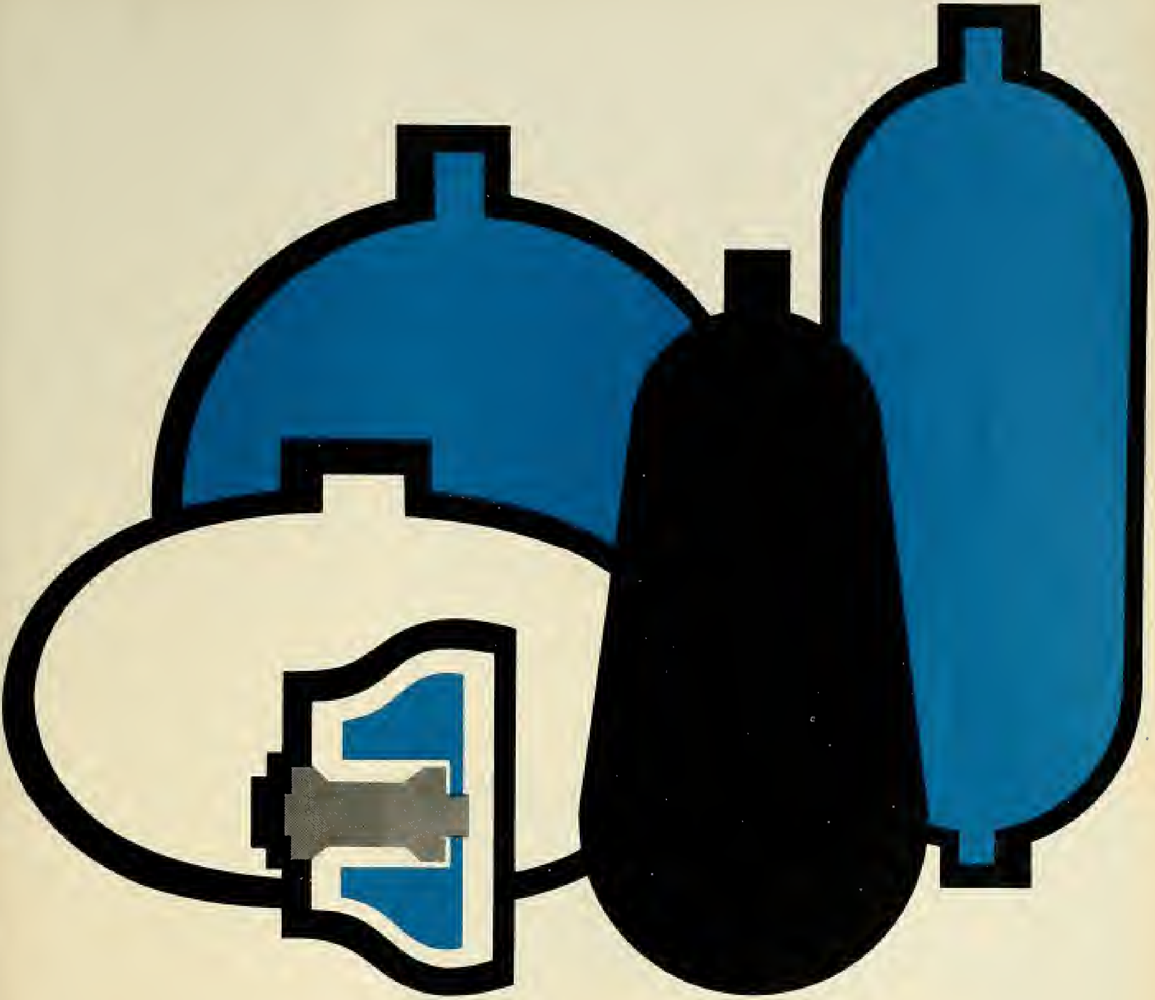
In discussing the future of both integrated and thin-film circuits in the design of underwater instrumentation, Liben pointed out that 63 different types of oceanographic measurements are required to characterize large bodies of water, the sea floor, and the water/atmosphere interface. Thus, he asserted, electronic instrumentation must play a major part in the collection of such data but must be designed for minimum size, weight and cost and for maximum reliability and accuracy. He said that only through state-of-the-art circuitry can all of the attributes be obtained.

For size/weight reduction, micromin circuits offer two opportunities for significant gain: direct exposure to pressures at depth or greatly reduced pressure-vessel size and weight. Thin-film units, Liben said, have demonstrated satisfactory operation under pressures of 30,000 psi. With similar-function circuitry employing discrete components, each individual part must be tested under pressure and few can be employed in their conventional form. When using pressure vessels, a factor-of-25 size reduction for a given measuring device (readily obtainable using current mircomin techniques) reduces the weight of the required steel housing from 122 to 5 lbs.

Due to the vast reduction in discrete parts, connections, and case and lead seals, integrated circuits provide an intrinsic high realiability, he asserted. APL and suppliers' tests have shown mean time between failures for integrated circuits (after screening by an incoming inspection and burn-in) of 0.0040% per 1,000 hours at 40°C.

Because of the size/weight improvement using micromin circuitry it is possible to employ many more circuits in a given volume, thus expanding both measurement and communications capability without a cabling or handling penalty. Through the use of micromin electronics, said Liben, a multiplicity of signals can be converted readily to FM/PCM (or digital) form for transmissions on a single wire using time-sharing multiplexing. Or, frequency signal separation could be employed over a single wire, using FM discriminator techniques at the receiving end.

Finally, said Liben, micromin design of instruments offers the practicality of precomputation before transmission or the direct input of digital data to computers at the receiving end.



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Fresh Details on Lunar Orbiter

Cape Kennedy—Mission details for the NASA *Lunar Orbiter,* slated for launching sometime this summer, have been released by NASA and the Boeing Company, prime contractor for the spacecraft.

Information developed by the lunar scanner as it "skims" the Moon's surface at a 25-28-mi. altitude will be used in conjunction with outputs from the *Surveyor* soft-landing mission to come up with a composite picture of potential landing sites for future manned lunar flights.

The *Lunar Orbiter* will "look" at the Moon through two eyes—a set of lenses which will give both wide-angle and telephoto sightings of the Moon. The first, an 80-mm wide-angle unit, will scan an area of some 350 sq. mi. for each picture. The other, a 24-in.-focal-length telephoto lens, will produce a photo of about 20 sq. mi., showing details down to about nine square feet—the size of a card table.

Photos will be made on film, and developed onboard by a single solution processor. The negatives resulting will be scanned by a light beam, as in normal wirephoto services, and the light passing through the negatives will be converted into electronic signals for transmittal to Earth.

Plans call for the last picture to be transmitted by the *Orbiter* about 30 days after launch. But other functions of the mission include the measurement of radiation near the Moon and the detection of micrometeoroids. These functions will continue for another 11 months beyond the end of the photo mission.

Mission plan—Industry rumors place the time of the *Lunar Orbiter* launch as mid-July, although there is as yet no official word. For the shoot, an *Atlas-Agena* launch vehicle will lift the *Orbiter* into a translunar trajectory. Here, a gimballed engine will provide two mid-course trajectory corrections, and later put the craft into lunar orbit.

Compressed nitrogen will be used in small jets to provide full three-axis stabilization and attitude control. Pitch and yaw reference will come from solar sensors, and roll reference will be obtained from tracking the star Canopus. When the Sun and the star are hidden from sensors, an onboard inertial reference unit will provide attitude reference.

Solar panels will power the craft and charge its nickel-cadmium batteries, which will provide power when the *Orbiter* is hidden by the Moon from the power-producing sunlight.

Flight control—Control center of the spacecraft is the flight electronic control assembly. The unit interfaces with all subsystems, and it issues all commands stored in the craft's onboard memory units before launch, or transmitted during flight. Some 120 cordwood modules and 600 integrated circuits are used in the 17.5-lb. assembly.

Programmer—*Orbiter's* flight programmer is a serial data-processing system said to be more advanced than any yet developed for space probes. It contains a 2,688-bit magnetic core memory with serial-bit random word access.

The programmer also provides spacecraft time to a stability of one part in 10^6 per 16 hours.

Memory storage requirements have been reduced to 75% of those required by a conventional 128-word memory by the use of address modification and memory subroutines. In addition, the use of work locations in the memory for time-counting, integrating, and magnitude and event-time storage has slashed the needs for active logic circuits.

The resulting system, says the contractor, offers several benefits: flexible programming or reprogramming of spacecraft events and/or time of execution; minimum ground-to-spacecraft transmission; and multi-use command word format.

Basic design philosophy included an Earth-to-spacecraft communication rate of 20 bits/sec.; high long-time reliability; low power consumption; several repetitive routines each program cycle; time or magnitude comparison; magnitude computation of position and velocity; minimum ground-space communication; issuance of 120 different commands; and full control of 8 hours of lunar orbit and the entire photo sequence without ground instruction.

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see pages 35-42

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No Soviet Animals for Moon

The possibility of the Soviet Union landing an animal on the Moon prior to manned exploration has been discounted by *Voskhod I* physician/cosmonaut Boris Yegorov.

Expressing his own feelings about the suggestion, which was ventured by cosmonaut Gherman Titov, Yegorov said that nothing new would be learned by putting an animal on the Moon, nor would it be practical to study cosmic radiation by means of animals.

Yegorov, one of the experimenters for the recent Soviet *Cosmos 110* which was returned to Earth March 16 after a 22-day stay in an orbit which took it into the Van Allen radiation region, said that as long as cosmonautics exist, there will be experimental animals in space flight.

However, he cited the difficulties in putting such animals on the lunar surface, including the problem of getting the animals back into the capsule, and the danger of contamination of the Moon's surface before it can be examined by scientists.

The eight-day weightlessness period required for a round trip to the Moon involves nothing new, he said, and the other area of possible biological difficulty—cosmic radiation—can be studied on tissue cultures by microorganisms or by using physical measuring devices.

Other Soviet space scientists commenting on the recent dog flight reported that there were no symptoms of disturbances due to cosmic radiation on the recent flight, nor were pathological changes observed.

Electrocardiograms taken after the flight were apparently satisfactory, Yegorov said, although the doctor reported that during the flight and toward the end of their stay in orbit, the dogs' normal rhythm of heartbeat was slightly upset. While arrhythmia occurs under normal circumstances, the doctor noted that it had become more pronounced during the flight.

However, normal heart rates and respiration rates were observed. There were some minor changes.

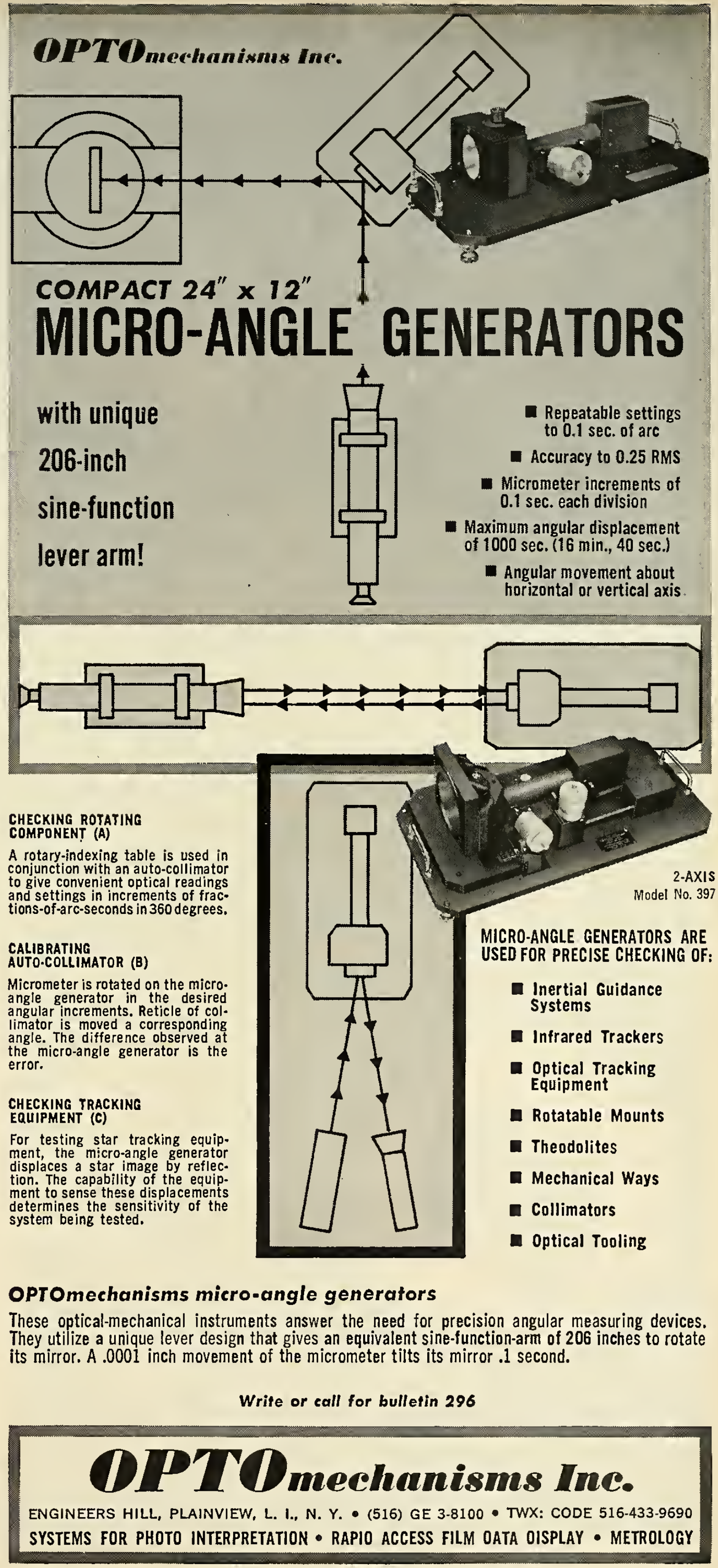
The dogs apparently were dehydrated when they were recovered; scientists reported they evidenced great thirst, a phenomenon also experienced in manned spaceflights.

The Soviets also were testing a new system for processing medical information obtained during the flight, TASS reports indicated. Onboard biomedical data was processed and sent to the ground on command twice daily.

New Propellants Introduced

A new family of cross-linked nitrocellulose-based propellants is out of the development phase at Hercules Powder Co.

Named Hercopel-B, the propellants have the highest energy attainable with a given fuel and exhibit excellent mechanical properties over the −75° to 160°F temperature range. Hercules officials say the binder is a particularly suitable vehicle for ultra-high-energy fuels now in development.



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House Group Aims To Make Space Policy

Actions of a subcommittee of the House Space Committee are bringing into focus the question of whether Congress has a place in making major policy decisions for the space agency or whether its function is simply to accept or reject Administration programs.

The House Subcommittee on Space Sciences and Applications is recommending redirection of funds in NASA's FY 1967 authorization bill to put emphasis on Mars exploration at the cost of dropping a proposed *Mariner* launch to Venus (M/R, March 21, p. 15). Joseph E. Karth (D-Minn.), chairman of the subcommittee, expressed his feeling that "we can discharge our responsibilities to the American people only if we are prepared to consider alternatives and to make the hard policy decisions that may be required."

The subcommittee plan, which would shift an additional $22 million to pre-*Voyager* technical work, as well as provide $20 million for a landing probe on the *Mariner* '69 launch to get precise data on the Martian atmosphere, was to be presented to the full committee late last week. The $42 million involved was to come from other programs in the Office of Space Sciences and Applications, including $18 million from the Venus probe, $1.5 million from the fifth *Orbiting Astronomical Observatory*, $10 million from launch vehicle procurement, $5 million from supporting research and technology, and $3.5 million from OSSA administrative operations.

In discussing the subcommittee's feelings about the planetary exploration program, Karth pointed out that the Soviets have not missed a single launch opportunity to Mars or Venus since 1960—launching at least six probes toward Mars and nine toward Venus.

While apparently none of the 15 or more Soviet attempts have met with much success thus far, Karth observed that, in terms of number of launches, the Soviets have committed about 10% of their total space effort to the planetary program, compared with the approximately 1% of the United States program. Success will inevitably come to the Soviet efforts, he predicted.

"The United States may be forfeiting its chance to acquire some of the most exciting information about the solar system during the next few years," he emphasized.

The fault, he indicated, is in the present level of funding for the *Voyager* and Mars efforts, which is so low as to lose the additional two years now available for concentrated preliminary work because of the postponement of the *Voyager* mission.

The *Voyager* project "is destined to become one of the most complex and difficult ever undertaken by NASA," Karth predicted. He added that the program probably will run to $3 billion or more during the next decade.

Inadequate preparatory work has been the one single feature common to all NASA's least successful spacecraft programs, Karth said. Further, except for two *Mariner* spacecraft—one of which performed for half the planned lifetime of a *Voyager*—all

(Continued on page 23)

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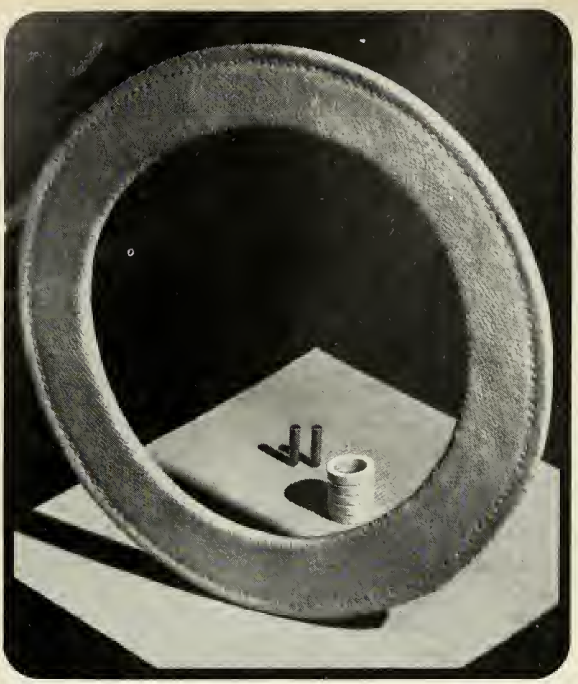
Which of these R/M characteristics



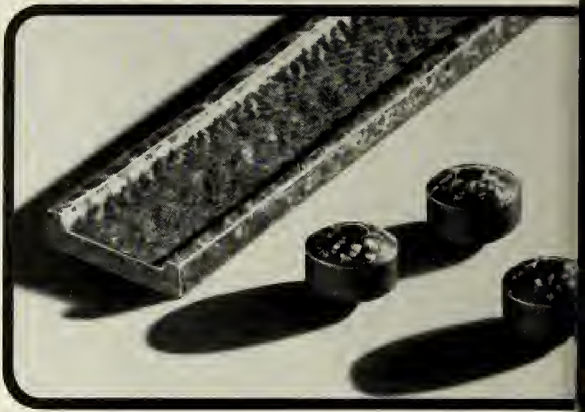
Cryogenic Materials (LOX compatible)

Characteristics: Resilient; zero moisture absorption; excellent aging properties; chemical, fuel and solvent resistant; anti-stick; can be used to —423°F.

R/M 601—unsintered TFE-impregnated woven asbestos fabric—for use as gaskets on pipe lines, valves, ducting and pressed metal covers.

R/M RL-279—unsintered TFE-impregnated woven asbestos folded gasket —made from R/M 601 and used where exposed cut fibers are undesirable.

R/M 3-TF00 and 4-TF00—unsintered TFE-impregnated braided asbestos valve stem packings—for use on propellant lines.

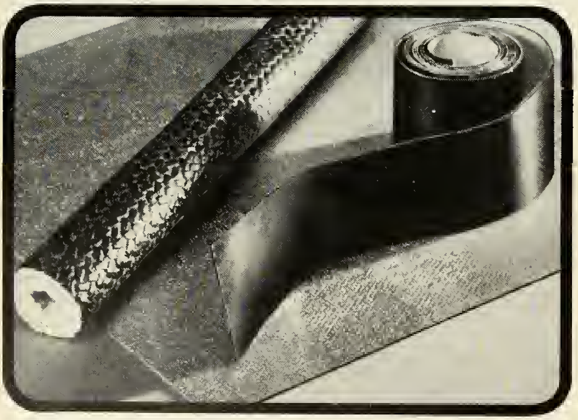


TFE-asbestos Anti-Friction Components

Characteristics: Low coefficient of friction, excellent insulating qualities in range of —450° to 500°F; chemical, fuel and solvent resistant; zero moisture absorption.

R/M RL-816 Channel Tape—sintered TFE-impregnated, wire-inserted, braided asbestos—for use as clamp liner or rub strip on cable controls and electrical harnesses.

R/M RL-742 Grommet—sintered TFE-impregnated braided asbestos, die-formed and slit—for use as guide when cable controls pass through compartment closures.



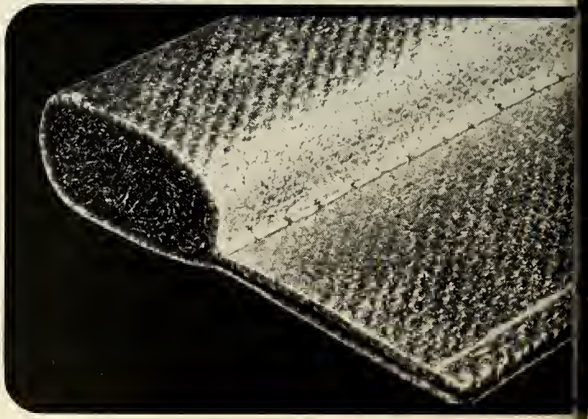
Blast Barrier Materials

Characteristics: Withstands blast temperatures and velocities; resist LOX and N_2O_4 propellant splashes.

R/M Ablatape®—homogeneous or asbestos-reinforced—for wrapping umbilical and propellant lines, valves, etc., in blast area. Conforms to irregular shapes and is easy to install.

R/M Ablatube®—homogeneous or asbestos-reinforced—for slip-on covering of umbilical and propellant lines in blast area.

R/M RL-638—wire-inserted woven asbestos fabric—for wrapping and clamping around valves, regulators and other equipment near launch pad. Is highly reflective, will not support combustion.



Tadpole Seal

Characteristics: Metallic mesh helps provide resiliency at temperatures above limits of elastomeric materials; resists penetration of 2000°F flame for 15-30 minutes.

R/M RL-819 Seal—metallic mesh core with a woven asbestos jacket coated on inside with a high temperature, resilient elastomer and on the outside with a highly reflective agent—used as a seal where high resiliency is required.

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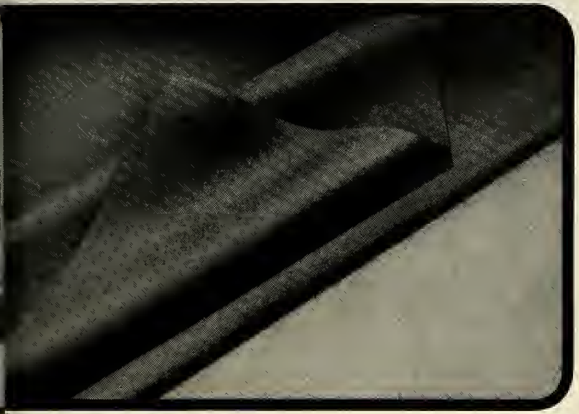
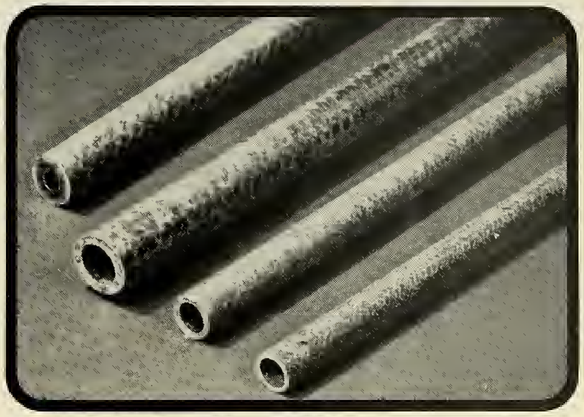


Radioactive Shielding Material

Characteristics: Shields gamma rays; extremely flexible; has ⅓ the radioactive absorption capacity and ⅓ the weight of a pure lead sheet of same thickness; is an antivibration and sound absorption material.

R/M RL-1736—neoprene/lead sheet material—used to protect against radioactivity when wrapped around pipe or draped over unusual shapes. Also as a vibration and sound dampener.

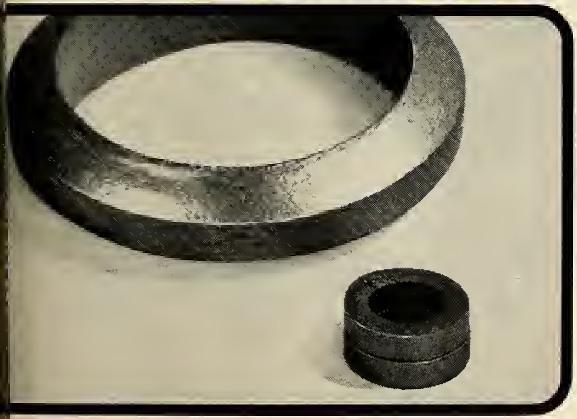


Protective Covering Material

Characteristics: Flexible; zero moisture absorption; excellent aging properties; chemical, fuel and solvent resistant; anti-stick; can be used to —423°F.

R/M RL-209—Sintered TFE-impregnated Braided Asbestos Tubing—a protective covering for pipe hangers, battery and other electrical or mechanical cables.

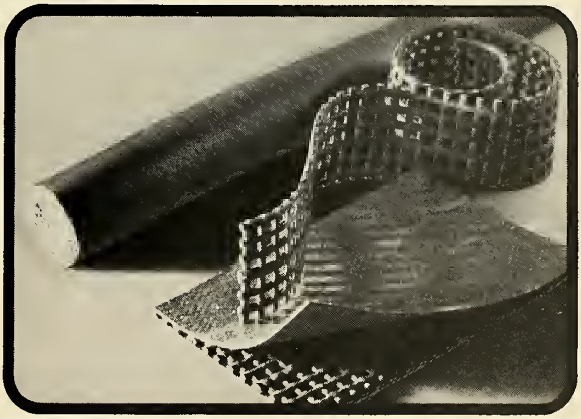
Low coefficient of friction allows freedom of movement through expansion and contraction. Prevents electrolytic reaction when used with dissimilar metals as well as degradation of metals in a corrosive atmosphere.



High Temperature Packing Rings

Characteristics: Resist temperatures to 1000°F, have minimum volume loss.

R/M CL-7029—AAA grade wire-inserted, braided asbestos containing a lubricant with a minimum amount of organics. Used as valve packing, and to prevent leakage in telescoping joints on hot lines such as exhaust manifolds.



Silicone Sponge Materials

Characteristics: Sensitive, lightweight, good aging qualities, ozone resistant, can be used in temperatures from —100 to 300°F.

R/M RL-524—Silicone Sponge Rod—used as a compartment seal, insulation, or as the core of a tadpole seal.

R/M Silicone Sponge Waffle Insulating Material—tape or sheet—is an effective insulating material, provides good shock absorbing qualities. When sandwiched between two sheets of RL-638, it becomes a light-weight insulating blanket with a highly reflective surface.

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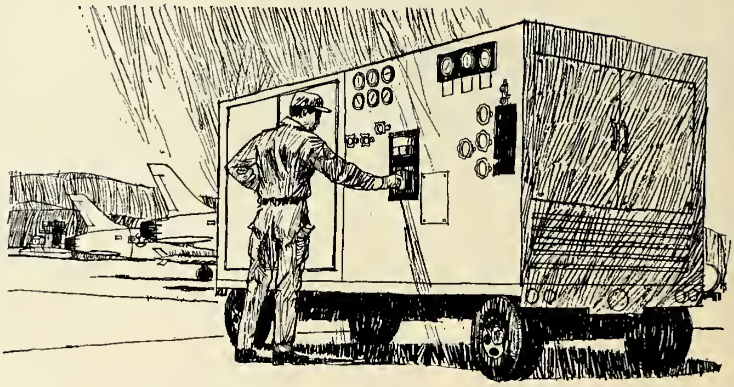

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Compared with high pressure cycle plants, the AiResearch LOX/LN_2 plant is 60 percent lighter, 40 percent smaller, and begins production in under three hours—less than half the normal pull-down time.

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complex spacecraft have quickly had substantial failures.

Unless NASA is able to reduce failure modes by an order of magnitude between now and 1973, he predicted, "the *Voyager* mission cannot be expected to succeed."

Sterilization, development of long-life electronic and electro-mechanical components, power supplies and other equipments all are problems which face NASA.

Inclusion of a landing probe on the 1969 Mars *Mariner* mission would yield considerable benefit to the *Voyager* program, Karth indicated. Not only would it necessitate facing the sterilization problem early, but it would give NASA experience in such areas as capsule separation and communications relay from one spacecraft to another.

This "smaller-scale" program would help define the problems which must be faced with *Voyager* and mistakes would be much less costly, he said.

Most important, however, would be the clarification of areas of uncertainty about the Martian atmosphere which will have a bearing upon many aspects of the design of the *Voyager* landing capsule, the mission profile and the weight of the scientific payload that can be landed on the surface of Mars.

Indications are that the Office of Space Sciences and Applications would approve such a probe if the money were forthcoming. Jet Propulsion Laboratory and Ames Research Center, which would be expected to do the work, have endorsed the proposal already.

In recommending that NASA drop the 1967 *Mariner* flyby to Venus, Karth said that the fact must be accepted that "the attainment of one goal sometimes requires sacrificing others."

"Unfortunately the Venus mission has all the appearances of being both a makeshift and an afterthought," he said. "The main purpose seems to be little more than an urge to do something—anything—between now and 1969 in the planetary area."

With no firm plans for future exploration of Venus, Karth said, the subcommittee feels that NASA should concentrate its efforts on achieving successful *Voyager* missions to Mars.

The subcommittee hopes to achieve its goal by keeping NASA's authorization level at the same as that already approved by the Administration and Bureau of the Budget, recommending only program changes within that level.

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Fluid Missile Control Moves Closer

Use of fluid control systems aboard future Army tactical missile systems has moved a step closer to operational status.

Engineers at the Army Missile Command (MICOM) at Redstone Arsenal, Ala., report another successful flight of a test-instrumented missile (TIM) carrying a single-axis fluid attitude-control system, and completion of an important phase in the test program.

Project sources say they are "highly enthusiastic" about the technique (see MISSILES AND ROCKETS' special report on fluidics, Feb. 8, 1965), and report that some early studies have been initiated to investigate possible application to specific missile systems. Operational use, however, should a specific requirement emerge, is viewed as at least two years away.

Applications—Most likely applications will be in new anti-tank missiles, artillery-type rockets, and short-range tactical ballistic missiles.

Future adaptation of fluid guidance and control systems to traditionally unguided artillery rockets, such as the *Little John* or *Honest John* types, could yield a significant improvement in accuracy, say Army engineers, for very little increase in cost.

For tactical ballistic missiles, there is considerable interest in fluid control systems for relatively simple, quick-reaction missiles such as *Lance*, with a range of about 45 mi., in comparison with longer-range (400 mi.) inertially-guided missiles such as *Pershing*. Engineers say the fluid systems would probably not find too much use in the more complex missile systems using inertial platforms and requiring considerably sophisticated circuitry to support guidance and control functions.

In general, fluid systems that use compressed air, hot gases or other fluids as the working medium and require none of the moving parts associated with conventional guidance and control units are viewed as an excellent potential route to accurate, low-cost, high-reliability missile guidance systems for a variety of missions. The units are also extremely rugged and are virtually free of acceleration-induced errors. Fluid control networks have operated successfully in test firings in which g levels greater than several hundred were experienced.

In comparison with electronic circuitry, they are also far less vulnerable to radiation effects and exhibit excellent high-temperature performance.

Program history—The last TIM flight was made March 15 at a MICOM research and development directorate missile range. The flight was the fourth for TIM, and the third that carried a fluid control system. The first test of a fluid system took place in September, 1964, the second in June, 1965.

The March 15 flight completed the roll control tests. The next round of firings, which will begin later this year, will attempt to extend capabilities into the pitch and yaw axes, probably using a hot gas system. Working fluid in the current control system is compressed air.

Scientists at the R&D directorate say the recent flight "demonstrated feasibility of the fluid gyros, amplifiers, and reaction jets in missile control. A large roll torque programmed into the missile at launch," scientists told M/R, "was held within fantastically small roll levels for the full period of controlled operation."

The disturbance torque around the roll axis was introduced by intentional misalignment of air vanes at the rear of the missile.

The recent flight lasted 20 seconds, according to the Army, including a 1-second, 20-g boost phase, four seconds of controlled flight, six seconds of free flight, and about 10 seconds for a parachute descent. The missile, fired at higher launch angles than in earlier tests to enable better parachute deployment, rose to 2,500 ft. and landed intact 7,000 ft. downrange. The TIM and working systems were recovered intact and will be reused.

How it works—In the TIM control system, a fluid rate sensor is used to provide differential pressure proportional to missile role rate. The

Test-instrumented missile in flight (left) and on launch platform at Army Missile Command, Redstone Arsenal.

differential is amplified through staging, roll position is sensed, and a supersonic air stream is deflected within the reaction-control system jets that drive the roll rate to zero.

Several design improvements were also incorporated in the missile for the March flight, according to the Army. MICOM engineers say that all components used were much smaller than those of previous tests, a major factor in making fluid systems competitive with microelectronic designs.

The control system was also altered to operate in a pulse-duration mode rather than a bi-stable mode. This provides a more directly proportional, quasi-linear output, engineers report, which also enables more precise control. They also point out, however, that in some systems designs, non-linear outputs would serve better.

It was also noted that by moving the missile's reaction-control jets from their previous position at the center of gravity to the rear of the airframe, behind the small control fins, a 90% gain in control was achieved.

The Army's inertial guidance and control laboratory at Redstone, part of the R&D directorate, is charged with management of the fluid control development. The control systems branch within the laboratory did the design and development work on the supersonic stages and the reaction jets used in the current system. The vortex gyro, low-level amplifier, amplifier stages, and the parachute system are vendor-supplied to the Army.

GAO Alters Refund Stand

The General Accounting Office has modified its position on voluntary refunds from defense contractors to align it more with that of the Defense Dept. itself, a report of the House Government Operations Committee discloses.

The long-awaited report on the GAO, which culminates a probe last year of defense contractor and DOD differences of opinions with the "Congressional watchdog agency," also applauds the agency for other actions it has taken in response to a number of criticisms voiced during the hearings.

The question of voluntary refunds, the subcommittee on Military Operations points out, has been interpreted in the past several ways by different Government agencies. The GAO now says demands for voluntary refunds will be limited to those cases in which cost of pricing information furnished by the contractor at the time of negotiation was inaccurate, incomplete, or non-current.

Previously, GAO called for voluntary refunds when contractors manifested a "take it or leave it" attitude at the time of negotiation, while DOD felt that in this "eyes open" situation a refund request would be a violation of the integrity of the contract.

In its report on the GAO probe, the committee said that not all of the criticisms leveled by defense contractors and agencies were supported, but that some appeared to have merit.

Authority not adjudicated—The report does not deal with fundamental questions concerning certain facets of GAO's authority, but is confined to procedural and other matters emerging from its review of GAO reports.

"GAO reporting practices have been substantially improved" since the subcommittee's hearings, the report concluded. Advances cited were a healthier climate of working relationships among the GAO, DOD and defense contractors, the reduction of GAO cases referred to the Justice Department, and other benefits.

As reported by Missiles and Rockets, the style, format and content of GAO reports has been changed (M/R, Dec. 13, p. 15). GAO reports are now couched in constructive terms rather than in critical words that tended to overstate findings in their negative aspects, the committee said.

In addition to being more businesslike and factual in tone, the report said, the GAO also is doing a better job in separating opinion from fact.

Reports also are being submitted less frequently and with better quality, the committee said. The number of published GAO reports for the last half of calendar year 1965 was one-fourth of the total number of such reports in the last half of calendar year 1964.

More beneficial and equitable procedural changes have been made in the preparation, distribution and release of GAO reports, the committee also noted. These included the inclusion of contractor and agency comments as appendices to the final reports, unless they are too voluminous, or do not pertain. In addition, if significant changes are made in the GAO findings or conclusions before the report is published in final form, the agency or contractor will have another opportunity to comment.

GAO's intention to refer cases to the Justice Department will not be announced in reports hereafter,

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see pages 35-42

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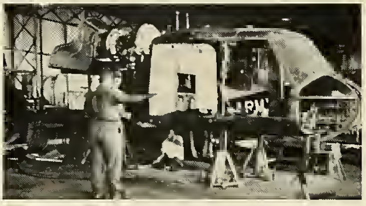

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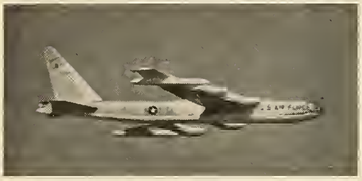

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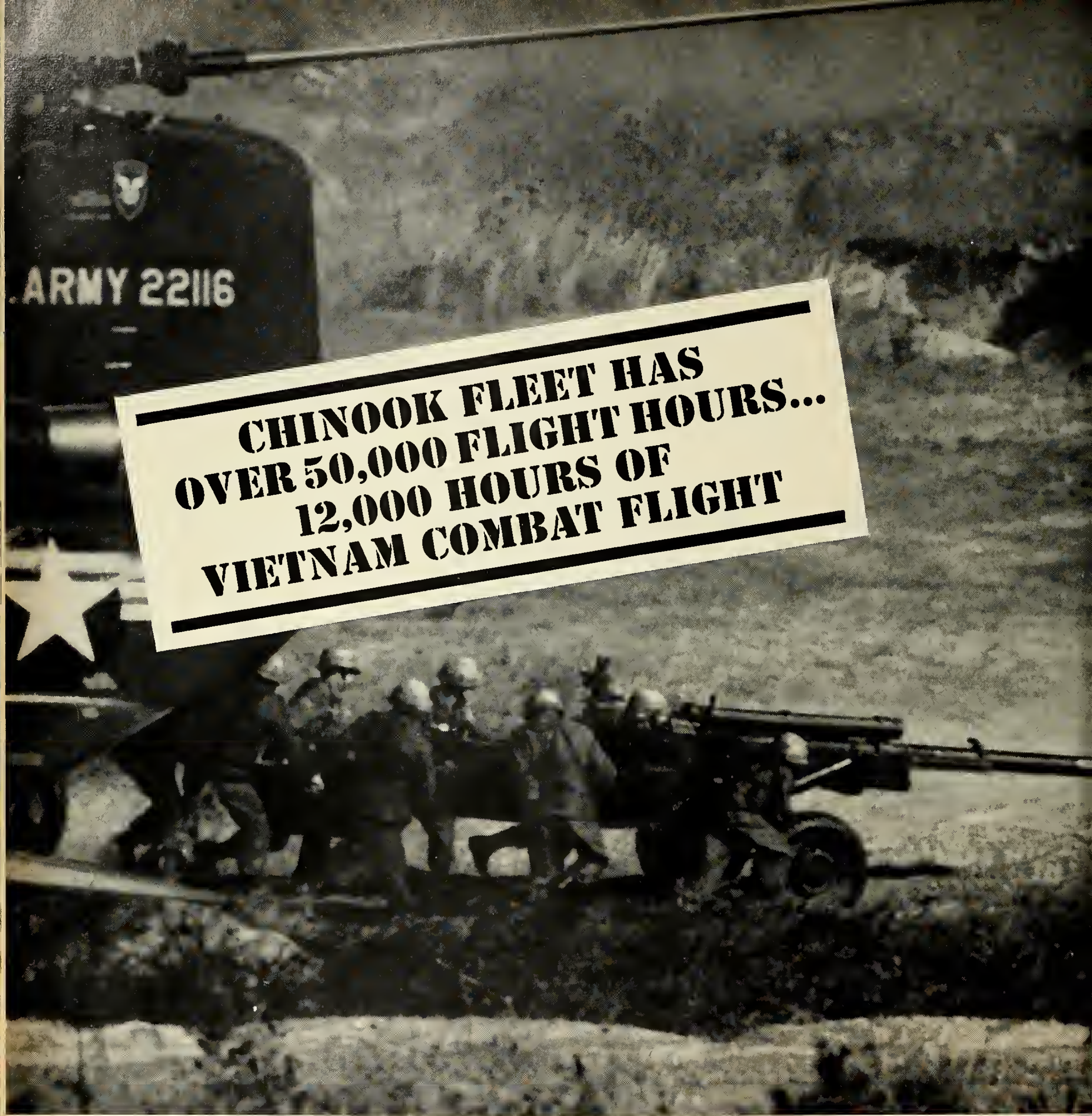

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Over 30 feet long and 7½ feet wide, the Chinook's cargo compartment can be loaded with Pershing Missile system components, or with infantry support weapons or the latest combat vehicles. Because of its large capacity, the Chinook reduces the number of helicopters needed for an air mobile mission, lessens traffic congestion and permits the use of smaller assault landing sites.

Now operating with the 1st Cavalry Division (Airmobile) in Viet Nam, the CH-47A Chinook has become the U.S. Army's standard medium transport helicopter.

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either, since such statements are easily misunderstood and can be damaging.

While there was some testimony from witnesses regarding the advisability of not releasing the GAO reports to the public, the committee expressed its view that since GAO reports deal with public business, they should be in the public domain unless security matters are involved.

Business secrets—Although the GAO has taken the position that the restraints on disclosure of contractor business data should not apply to reports they issue, Assistant Comptroller General Frank Weitzel has told the committee that all such cases will be reviewed by senior officials of the GAO and then released only if such disclosure is deemed necessary for the purposes of the report.

GAO also has discontinued disclosing the identity of individuals immediately responsible for actions or operations under criticism in the reports. The committee had voiced the opinion that individuals should not be singled out for censure in complex situations in which responsibilities were shared by many parties, and where honest differences of opinion may be involved.

Regarding the question of integgrity of Government contracts, brought up by the committee by the action of the GAO in demanding recoveries of payments from contractors not based upon legal grounds, the committee noted that the GAO has withdrawn from this position in the three cases involved.

Recommendations—The committee pointed out that some clarification is needed as to the roles of the Defense Contract Audit Agency and the GAO itself, and that a study should be undertaken so that duplicating processes do not evolve.

The group also asked for expedition of disputed cases by the DOD and GAO so that protracted suspension of payments to contractors for work performed does not occur. Some limitations on time in such matters could be included in Armed Services Procurement Regulations, the committee noted.

Another issue demanding corrective action is the lack of a cutoff date for contractor liabilities, the group said. "It would be appropriate for the DOD, the Department of Justice and the GAO to consult together and develop recommendations with respect to application of the statute of limitations to suits by the Government arising out of contracts, with the objectives that a fair procedure be adopted and that contracts be closed out after a finite period."

Another recommendation made by the committee was that the Bureau of the Budget should study the need for and advisability of a presidentially appointed Government procurement policy board to consider the direction and effects of procurment policies and Government programs on a Government-wide basis.

Long Initial Apollo Flights Set

HOUSTON—Unlike Project *Gemini* missions, the first two manned *Apollo* flights will be of long duration—12-14 days in space. The length of each mission, however, will depend on the continuing good performance of on-board spacecraft systems.

"The primary purpose is to exercise the spacecraft and crew in Earth orbit," says *Apollo* Manager Joseph P. Shea. The crew will get the "go" to continue the mission as long as the systems hold up, he added.

Extravehicular activity (EVA) and rendezvous and docking have been restricted from the early manned *Apollo* flights. Open-hatch operations and rendezvous and docking exercises with the Lunar Excursion Module (LEM) will begin with Block 2 *Apollo/Saturn-207*, according to Shea.

TV from space—Live television transmission of activities in orbit will be attempted on *AS-204*, using an RCA-built television camera. Black and white pictures will be transmitted at a scan rate of 10 frames per second, 320-line resolution to the Mission Control Center here, where they will be converted to 30 frames per second, 525-line resolution for commercial television.

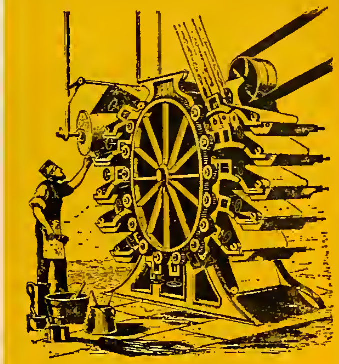
AS-204 experiments will be primarily medical in nature and "repeats" from *Gemini* missions, Shea said. Astronauts will continue to obtain terrain and cloud photography as they did during *Gemini*. A new experiment—in-flight nephelometer—will obtain measurements in size and number of aerosol particles floating within the spacecraft cabin for application to design of advanced (post-*Apollo*) environmental control systems.

The *Apollo* Command and Service Modules (C/SM) will be launched into an 85-130 n.mi. elliptical orbit about Earth, then circularized through a number of Service Module engine burns, Shea said.

The service propulsion system (SPS), which consists of a 21,900-lb. vacuum-rated-thrust space engine with multiple restart capability, will be ignited seven to eight times during the mission. "We may end up in an orbit as high as 200-235 n.mi. above Earth," Shea said.

collage

A random collection of fact, opinion and miscellany... some of it a blatant attempt to peddle the products and capabilities of Motorola's Military Electronics Division.



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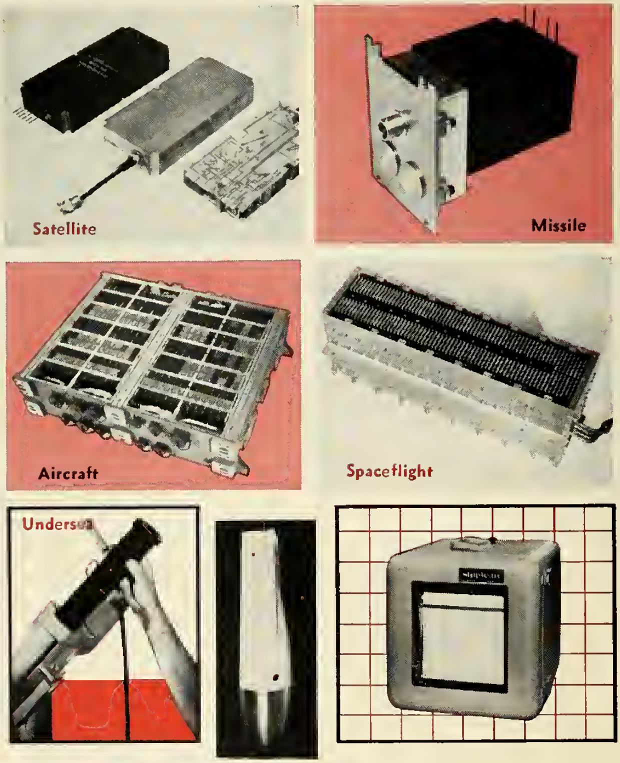
Continued on page 96

Apollo navigation equipment—An LX scanning telescope with 60-deg. field-of-view, and a 28X sextant with 1.8-deg. field-of-view—will be used by the *AS-204* crew in navigation exercises that will call for determining spacecraft orbital parameters without assistance from the ground, Shea said.

The crew will also check the "accuracies" of the navigation equipment, he said, by seeing "how well we can shoot (stars) with the sextant in low Earth orbit." There is some concern that inability to see stars in the day side of the orbit may complicate navigation using *Apollo* optical equipment (M/R, Jan. 10, p. 17; Jan. 24, p. 18).

S-band communications, backed up by VHF, will be checked out on *AS-204* and qualified for all follow-on Earth-orbital and lunar missions, he said. "For all communications at lunar range, we use the unified S-band communications system, which provides not just communications but tracking necessary for determining orbits from the ground."

Manned spaceflight network stations are now being equipped with *Apollo* S-band equipment that will start coming into operation with the *AS-204* mission, he said. Ten near-Earth stations in the net will be equipped with 30-ft.-dia. antennas for lunar missions. Three deep-space stations with 85-ft.-dia. antennas will take over communications and tracking when the lunar vehicle is about 10,000 n.mi. out from Earth, Shea said.



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New Science Advisors Named

President Lyndon B. Johnson has named five new members to his science advisory committee.

The new advisors include: Dr. Ivan L. Bennett, Johns Hopkins University; Dr. Sidney D. Drell, Stanford University; William R. Hewlett, president of Hewlett-Packard Co.; Dr. Charles P. Slichter, University of Illinois; and Dr. Charles H. Townes, Massachusetts Institute of Technology.

The advisory committee is headed by Dr. Donald F. Hornig, special assistant to the president for science and technology.

Hybrid Rocket Probed

The internal ballistic effects created by spinning a hybrid rocket will be studied by United Technology Center under a \$50,000, 8½-month contract from NASA's Langley Research Center.

Spinning is often used as a method of achieving flight stabilization but the stresses created can have a detrimental effect on the propulsion functions. UTC has studied the spinning effect on metal additive loaded solid rockets and developed spin-stabilized units such as the new fourth stage *Scout* motor.

Martin To Build SNAP-29

Martin Co. will develop a radioisotope thermoelectric generator for use in short-duration Earth-orbital and lunar surface missions under an Atomic Energy Commission contract.

Estimated cost of the project, designated SNAP-29, is more than \$10 million. Sandia Laboratory is providing technical direction for the program.

The power source will be fueled with polonium-210 and will produce 400 watts of power. Weight will be about 400 lbs. This power level will be about 10 times greater than those of radioisotopic power systems now being developed by AEC.

XB-70 To Yield SST Data

An 18-month, \$50-million flight-research program using the Air Force's XB-70 will provide data for

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the supersonic transport program as part of the test objectives.

The joint flight program will start at the completion of the current XB-70 flight-test program this spring and involve both the Air Force and NASA's Flight Research Center, Edwards AFB.

Objective is to acquire experimental data on the flight dynamics, flight loads, structures, propulsion, air induction and environmental factors experienced by the huge plane.

Since the XB-70 is the only aircraft approximating the size and weight of projected SST's, NASA has installed instruments, recording equipment and other gear in the two existing aircraft. Air Force Systems Command's Aeronautical Systems Div. will direct the program.

EVA Propulsion Under Contract

A jet-gun using back-pack propellant supplies is being developed by Rocket Research Corp. for extravehicular applications by astronauts.

The system, being built under a $236,500 contract from the Manned Spacecraft Center, will increase the maneuvering ability of an astronaut by a factor of 25 over current equipment, the firm says.

The gun will use a mixture of hydrazine and water coupled to the Shell 405 catalyst, which spontaneously decomposes hydrazine. The water additive functions to cool the exhaust gases.

The system will have three small motors—two rated at one-lb. thrust and one at two-lbs. thrust—actuated by a hand-held control. The contract is the latest in a series on the hydrazine-Shell 405 technology developed by Rocket Research. Other applications include satellite attitude control and gas generation.

First OAO, AC-8 Launch Due

The launch of two major unmanned space missions, the first *Orbiting Astronomical Observatory (OAO) and Atlas/Centaur-8* booster, will be attempted from Cape Kennedy this week.

The *OAO* is scheduled for no earlier than March 28, with *AC-8* to follow one day later.

OAO, which NASA calls the most advanced, complex spacecraft ever built by the U.S., is designed to gather data on the Universe from outside the Earth's atmosphere.

The 3,900-lb. spacecraft will be placed in a 500-statute mi. circular orbit by an *Atlas-Agena* booster. Its orbital period is expected to be 101 minutes.

It carries four experiments to study stars and other celestial objects in the ultraviolet, X-ray, and gamma ray regions of the electromagnetic spectrum. These radiations have shorter wave lengths and higher frequencies than visible light and cannot be studied by ground-based observatories.

To date, the total amount of direct scientific observation of those regions from sounding rockets and balloon flight is less than an hour.

The main body of the spacecraft is a 10-ft.-long, eight-sided cylinder, which is 7 ft. wide; a central tube four ft. in dia. running through the main body carries 1,000 lbs. of astronomical observing instruments. With its solar panels extended, the overall width of the spacecraft is 21 ft.

The four experiments were developed by the University of Wisconsin, Massachusetts Institute of Technology, Lockheed Aircraft Corp. and NASA's Goddard Space Flight Center.

The Wisconsin experiment, a series of seven telescopes, is designed to study stars and nebulae in the

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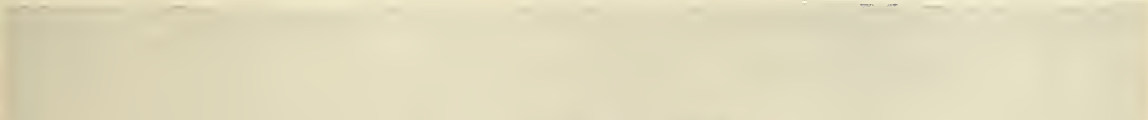

PRIME lifting body, a step toward this goal, is scheduled for Air Force flight tests in space this year.

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Republic Making Biggest-Yet Beryllium Beam for MSFC

"Largest" beryllium box beam, 8 ft. long by 1 ft.^{2} in cross-section, is being manufactured by Republic Aviation Div., Fairchild Hiller. Beam is composed of 12 formed sheets of beryllium, external stiffeners, and steel-jig attachment parts to accommodate the ultimate load of more than 20 tons. A current Marshall Space Flight Center study and tests are aimed at determining the structural integrity of the beam.

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ultraviolet spectrum. It occupies the forward-looking or top portion of the experiment tube.

The aft section contains the MIT, Lockheed, and Goddard experiments, which will study the X-ray and gamma-ray spectral regions.

Centaur flight—The prime objective of the *AC-8* flight is to test the restart capability of the liquid-hydrogen upper stage's RL-10 engine.

If the mission is successful, the next *Centaur, AC-7*, will be used for the first flight of the *Surveyor* lunar soft-landing spacecraft. That flight is now scheduled for June.

The *Centaur 8* mission is preceding *Centaur 7* because of delays in getting the first *Surveyor* spacecraft ready for flight.

The *AC-8* vehicle will carry a mass model of the *Surveyor* which will be injected on a simulated lunar transfer trajectory following a 25-min. coast period in Earth orbit. The model will not impact on the Moon, but will be sent into a highly elliptical Earth orbit extending more than 500,000 mi. into space.

Primary objectives of the Wisconsin *OAO* experiment to be flown in March are to determine stellar energy distribution in the spectral range of 3,000 to 800 angstroms by making observations of about 200 stars of all spectral types, selected to obtain a representative sample; to make up to three observations on selected stars to check observational consistency and to establish that the energy distribution is not intrinsically variable; and to measure emission-line intensities of diffuse nebulae in the 3,000-800Å spectral region.

Secondary purposes of the Wisconsin experiments are to study the variation of interstellar reddening in the far ultraviolet by observing stars of similar spectral type selected on the basis of location; to investigate the limb darkening by measuring the variation of light intensity with time during eclipses of binary stars; and to investigate in the ultraviolet the intensity fluctuations of very short duration, recently observed in certain stars and suspected to be associated with flare activity.

Instruments—The instruments to carry out these measurements and observations are:

—Three basic optical systems: a multicolor filter-photometer system consisting of four 8-in. telescopes, each feeding a separate three-color filter photometer and detector; a multicolor filter photometer for nebulae, consisting of a 16-in. telescope and associated filters and detectors; and two auxiliary scanning spectrometers using objective gratings of about 6- by 8-in. aperture.

—A stellar-photometer system consisting of four 8-in. F/4 off-axis paraboloid telescopes located in pairs on diametrically opposite sides of the experiment cylinder.

—A nebular-photometer system. The telescope is a single 16-in. F/2 parabola whose optical axis coincides with the axis of the experiment cylinder. The associated photometer is at the prime focus, and a selectable diaphragm will determine the field of view.

—Two scanning spectrometers, located on diametrically opposite sides of the experiment cylinder, are identical except for the amount of angular rotation imparted to the gratings and the angles at which the gratings are blazed.

—A detector system consisting of photomultipliers. The light source for calibration consists of a bistable slide containing a phosphor activated by a suitable radioactive source which will serve as a calibration standard for photometry, and an emergency dark slide to protect the sensor.

—Electronic equipment. The stellar and the nebular motometer systems have two field-stop apertures each. The stellar system has viewing angles of two and 10 minutes of arc; the nebular system of 10 and 30 minutes of arc.

NASA Names New Advisors

A temporary science advisory committee to advise NASA on the conduct of future space projects has been established.

The committee was formed because, in the next generation of space projects, NASA will need new policies and procedures and possibly new organizational arrangements to enable scientists to participate, the space agency said.

It will be chaired by Dr. Norman F. Ramsey, a Harvard University physicist.

The group will study how best to conduct such programs as the *Voyager* planetary spacecraft including the automated biological laboratory, the post-*Apollo* lunar exploration program, and national space astronomy observatories—a project recommended by astronomers in which 120-in. telescopes would be orbited for space astronomy. These are projects which have been recommended by the Space Science Board of the National Academy of Sciences.

In addition to Ramsey, other members are: Dr. George W. Beadle, University of Chicago; Dr. Leo Goldberg, Harvard University; Dr. Jesse L. Greenstein, California Institute of Technology; Dr. Harry H. Hess, Princeton University; Dr. Howard Johnson, Massachusetts Institute of Technology; Dr. Gordon J. F. MacDonald, University of California, Los Angeles; Dr. Horace W. Magoun, University of California, Los Angeles; Dr. Nichols U. Mayall, Kitt Peak National Observatory, Tucson, Ariz.; Dr. Colin S. Pittendrigh, Princeton University; Dr. Martin Schwarzschild, Princeton University; Dr. Charles Townes, Massachusetts Institute of Technology; and Dr. James A. Van Allen, University of Iowa.

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Stress & Dynamics Analysts

Perform stress and dynamic analysis of spacecraft, missile, and ground electronic and electromechanical equipment. Includes all related assignments such as performing detail analysis, testing, and establishing design criteria.

Electronics Packaging Engineers

PRODUCT ENGINEERS to create design concepts and supervise their execution.

DESIGN ENGINEERS to develop conceptual design layouts ond supervise the accomplishment of detail drafting.

ENGINEERS to function in close-knit teams engaged in packaging design of the whole spectrum of aerospace electronic and electromechanical hardware to include: transmitters, receivers, decoders and encoders; digital and analog circuits; RF equipment and antennas; electronic power supplies; battery packs; power converters and inverters; electrical ground equipment; consoles and displays; logic circuits; memory circuits; computing circuits; controls circuits; sun sensors and horizon scanners; inertial equipment; electromechanical drives and actuators.

Familiarity with state-of-the-art packaging techniques, such as multi-layer etched boards, cordwood modules, wire-wrap, and flex circuits as applied to packaging of integrated circuits and discrete components is of primary benefit.

PRODUCT ASSURANCE

Senior Quality Engineers

With a degree in ME, AE, or EE, to work in the following areas:

Propulsion

Perform technical monitoring and associated Quality Assurance tasks relative to liquid rocket engine development, fabrication, qualification, and test. Knowledgeable in propulsion test instrumentation, calibration, and systems to measure temperature, flow, pressure, force, and vibration. Duties include presiding over all technical direction, including MRB, failure analysis, and corrective action.

Mechanical-Structural

Perform technical Quality Assurance planning and design review of mechanical subsystems and structures for spacecraft. Experienced in design, manufacturing processes and techniques, and quality control of welded aluminum, magnesium structures, and related special process applications. Additional knowledge and experience in physical metallurgy, dynamic mechanisms, and mechanical integration and testing desired.

Communications

Perform technical Quality Assurance planning and design review of spacecraft communication subsystems and systems. Evaluate system configuration and associated test equipment. Knowledge of fabrication process and Quality Control techniques as applied to communications electronics in the RF spectrum and propagation phenomenon necessary. Duties include presiding over all technical direction of a variety of space communication subsystems within Quality Assurance including MRB, failure analysis, and corrective action.

Systems Test and Test Equipment

Perform overall review of spacecraft systems, electronic test procedures, methods, and associated test equipment. Experienced in production test, black box environmental and qualification test, and spacecraft system integration, test, checkout, and launch.

Electronic Aerospace Ground Support Equipment

Responsible for technical direction of Quality Assurance activities from design through checkout of complex space vehicle, electrical ground support, and checkout equipment. Experienced in EAGSE fabrication methods, workmanship standards, test procedures, checkout, and ground station installation.

COMMUNICATIONS

Signal Processing Engineers

Design and develop sophisticated communications systems and components. Signal conditioners, analog and digital encoding and decoding, modulation tracking and carrier tracking phase lock loops, and multiphase modulation are involved in tracking, telemetry, and command equipment which includes but is not limited to space applications. BSEE or MSEE.

Communication Equipment Design Engineers

Several years' experience in design, development, and analysis in the following areas: microwave components-filters, diplexers, stripline; antenna systems-spacecraft/missile/aircraft systems, phased arrays, reflector feed systems/solid-state transmitters, receivers, phaselock loop techniques, cavity techniques, very wide and very narrow band circuits, circuit engineering, and modulation techniques. BSEE or MSEE.

Communication System Analysis Engineers

Conceptual design, analysis, and synthesis of wide variety of digital and analog communication systems, employing coding, modulation, and statistical communication theory. Systems include integrated coherent-carrier systems, phase lock demodulation (restrictive/non-restrictive), communication satellites, and deep space probes. MSEE or PhD.

Senior Communication Engineers

Design, analyze, and manage communications systems and evaluate scientific and military applications of communication techniques for aircraft, spacecraft, and underwater craft use. BSEE, MSEE, or PhD.

Telemetry Circuit Design Engineers

Design a wide variety of analog and digital signal processing circuits for spacecraft digital telemetry equipment. Experience should relate to the design of analog-to-digital converters, analog and digital multiplexers, logic and data storage. Familiarity with microelectronics desirable. BSEE or MSEE.

Telemetry System Engineers

Experienced in the functional and logical design of analog and digital telemetry systems. Familiarity with design, development, application, and evaluation of spacecraft instrumentation systems. Experienced in the design of data systems to interface with a wide variety of data sources including scientific experiments and engineering measurements.

ECM Equipment Design Engineers

Experienced in design analysis in the following fields: ECM system analysis; transmitters — solid state and vacuum tubes; distributed amplifiers; and modulation techniques. BSEE or MSEE.

DIGITAL SYSTEMS

Circuit Design Engineers

Analytical ability to develop advanced but practical circuits and subsystems in conjunction with logical, metallurgical, and semiconductor groups using discrete, thin-film, multi-chip array, integrated, magnetic, radiation resistant, and hybrid circuit techniques.

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MICROELECTRONICS

Thin-film Process Engineers

BS or MS in Physics or Chemistry. Minimum 3 years' experience in thin-film fabrication. Responsibilities include process engineering on thin-film techniques used in microcircuit fabrication. Experience in compatible thin-film techniques and the application of thin-film components to monolithic integrated circuits. Experience in preparation of both resistive and capacitive structures required.

Microcircuit Packaging Engineers

BS or MS in Physics, Chemistry, Metallurgy, or Mechanical Engineering. Responsible for process engineering or assembly and packaging techniques in microcircuit fabrication. Familiar with the construction and sealing techniques of plastic, metal, and glass microcircuit packages. Must have sufficient understanding of semiconductor and thin-film phenomena to consider device performance implications of packaging. A good understanding of split electrode welding, ultrasonic bonding, and thermocompression bonding techniques required.

Diffusion/Epitaxy Process Engineers

BS in Chemistry or Physics and at least 3 years' experience in solid state integrated circuit development. Responsible for process engineering on diffusion and epitaxial techniques for monolithic integrated microcircuits. Good understanding of the device design and performance implications of these techniques. Some experience with dielectric isolation techniques, silicon, diffused pnp transistor fabrication, and MOS device fabrication desired.

Photoengraving Process Engineers

BS in Chemistry or Physics and at least 2 years' experience in the field of hybrid circuit fabrication. Will assume responsibility in process engineering on photoengraving processes used in thin-film hybrid and monolithic integrated circuit fabrication. Some understanding of device performance implications of these processes desirable.

High Frequency Engineers

BS or MS in Physics, Engineering Physics, or Electrical Engineering, with 2 years' experience in the development of high frequency circuits and microwave measurements. Assignment will consist of circuit design and evaluation of microwave integrated circuits, and development and application of strip line techniques for integrated circuits including physical layout and packaging.

Integrated Circuit Design & Analysis Engineers

BSEE or advanced degree and 2 years' experience in solid state circuit design and analysis. Will design complex solid state circuits and assume responsibility for transposing from development phase to production. Develop new methods of packaging and interconnecting integrated circuit arrays using thin-film techniques.

Advanced Process Engineers

MS in Physics or Electrical Engineering. Familiar with plasma physics, semiconductor technology, and thin-film deposition methods. Main responsibility will be to develop processes for the application of conductors and dielectrics to integrated circuits using advanced techniques such as sputtering, pyrolysis, and plasma technologies.

Thin-film Scientists

Advanced degree in Physics, Chemistry, or Chemical Engineering with 3-5 years' experience in active and/or passive thin-film device development, fabrication, spectrographic analysis, and electron microscopy. Develop advanced processes in circuits utilizing both passive and active devices. Engineers with BS in Chemistry and/or Physics are also needed to assist with the above projects.

MISSION ANALYSIS

Mission Analysts

Strong analytical ability and technical originality with broad background in flight mechanics, astronautics, missile guidance, and mission performance.

Astrodynamicists

Theoretical background in celestial mechanics, orbit determination, and/or related fields of Math, Physics, or Astronomy.

Guidance Analysts

Familiarity with techniques for missile guidance and experience in orbital mechanics, random processes, and statistics.

Trajectory Analysts

Familiarity with use of digital computation, analytically inclined, with background in space mechanics.

SPACECRAFT RE-ENTRY

Aerodynamicists

Applied aerodynamics involving preliminary design of re-entry vehicles and rocket boosters, re-entry trajectories and vehicle motions, estimation of aerodynamic coefficients and pressure distributions, analysis of hypersonic flow fields including effects of fluid injection. MS with 1 or more years' experience in aerodynamic theory including hypersonic flow.

Aerothermadynamicists

Engineers with related experience to analyze heat performance, ablation processes, and for synthesis of new computer programs.

Gas Dynamicists

Engineers with related experience to analyze shock waves propagating through ducts, fireball heating, gas and particle and exhaust plumes, and free molecule flows.

Re-entry Engineers

Re-entry systems engineers, analysts, program controllers and designers. Familiarity with the technical facets concerned with re-entry of a body into an atmosphere. Capability to integrate design criteria with engineering constraints and/or ability to complete design layouts of configurations are typical requirements.

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Structures Analysis Engineers

Determination of the strength and rigidity of advanced missile and satellite structures, pressure vessels, auxiliary and ground support equipment.

Dynamics Engineers

Experienced in determining dynamic loads and vibration characteristics of launch vehicles and spacecraft. Also, background should include dynamic response calculations and support for dynamic development tests.

Mechanical Designers

Design spacecraft structures and/or engines; make complex layouts; and perform liaison with structures, dynamics, and material specialists on structural problems.

MECHANICAL INTEGRATION & TEST

Senior Test Engineers

Responsible for conducting and directing functional, mechanical, structural, ordnance, transportation, and reliability tests on space vehicles and rocket engines. BS required.

Functional Test Engineers

Develop and conduct spacecraft functional tests such as separation, appendage deployment, and spin-up. BS required.

Test Design Review & Analysis Engineers

Provide analytic support to mechanical integration and test activities with particular emphasis on dynamics, mass property measurements, and alignments. Generate test requirements and concepts for unique spacecraft systems. Provide overall review of department test activities for technical adequacy. Requires MS in ME, AE, or related fields.

Pneumatic Test Engineers

Perform detailed test planning; develop test procedures; supervise the performance of qualification, reliability, and acceptance tests; analyze test results; write test reports, and recommend design changes for pneumatic subsystems and systems. Knowledge of cleanliness in pneumatic systems essential.

Dynamics Test Engineers

Develop and conduct development, acceptance, and qualification tests and model surveys on complete rocket engines, spacecraft, and transportation vehicles. BS required.

Structural Test Engineers

Develop and conduct structural tests to qualify spacecraft and rocket engines for the critical operational load and environmental conditions encountered during launch and operation. BS required.

SYSTEMS INTEGRATION

System Integration Engineers

Integrate communications, data handling, power and attitude control subsystems into the overall spacecraft system. Requires knowledge of system level testing and the ability to write system test procedures, function as a test supervisor, analyze test results, write test reports, and recommend design changes.

Communications Integration & Test Engineers

Perform detailed test planning, test equipment definition, supervise tests, analyze test results, plan launches, and direction in liaison capacity with ground station operator. Requires a knowledge of microwave components, solid state transmitters and receivers, TWT amplifiers, phase lock techniques, PM & FM demodulation, and coherent carrier systems.

GSE System Design & Integration Engineers

Perform design or integration of Electronic Ground Support Equipment used in conjunction with spacecraft systems testing. Requires understanding of computer utilization for system test and ability to do conceptual design of GSE systems, define specific sections of GSE, and specify detailed test requirements.

System Test Planning Engineers

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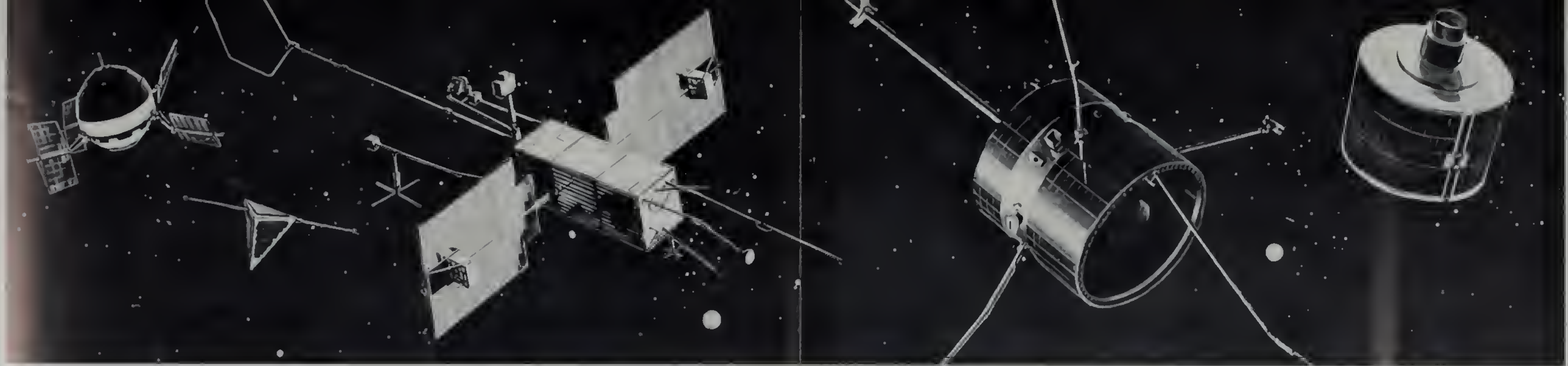

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Systems Programmers

Experienced in development and/or modification of control programs, i.e., supervisors, monitors, loaders, etc., for large-scale computing systems. Background in multiprocessors and multiprogramming desirable.

Scientific Programmers

Experience in programming high speed digital computers. Will assist in solution of problems arising in missile and space vehicle engineering, responsible for analysis, programming, and debugging of computer solutions. Requires BS or MS in Math, Physics, or Engineering.

Real-time Programmers

Software development for small or medium-size digital computers on real-time or near real-time applications. Prefer experience with real-time for handling instrumentation or telemetry data. BS in Engineering or Math.

SPACE VEHICLE ELECTRICAL SYSTEMS

System Design Engineers

Design complete space vehicle electrical systems. Requires basic knowledge of space power generation, conversion, distribution, and control; data handling and storage; telemetry and instrumentation; attitude control; command and communications; deployment, ordnance, separation, and sequencing. Familiarity with system test concepts, hardware design, and EMI control desirable.

Experiment Engineers

Design experiment/space vehicle interfaces; coordinate and prepare computer programs for data reduction and testing of experiments; plan and perform functional qualification, and flight certification testing of experiments; support integration and test of experiments on space vehicles; support experiment testing during launch operations; assist in the reduction and analysis of orbital experimental data.

Magnetic Control Engineers

Define and implement magnetic purity design requirements and control programs for space vehicle systems; perform magnetic purity analyses; analyze system and component magnetic properties; monitor system and component designs to control magnetic properties; develop practical test methods and techniques in controlling and testing magnetic field phenomena; determine test requirements and direct magnetic testing at system and component levels.

Electromagnetic Compatibility Engineers

Define and implement EMC programs on space vehicle systems; perform electro-magnetic interference prediction and compatibility analyses; develop interference specification requirements and advanced test methods; plan and implement attendant EMC R&D programs; evolve and monitor the implementation of EMC and FED-STD-222 grounding, bonding, shielding, and suppression criteria during system design.

Equipment Design Engineers

Define requirements for electrical integration hardware; design, develop, and test solid state switching and timer circuits using integrated circuit chips; package circuits to meet rigid environmental and EMI requirements; analyze breadboard and engineering model test data; define and evolve subsystem interfaces as part of the design of interconnection circuitry and cabling utilizing computer-augmented design and tabulation techniques.

SUPPORT SYSTEMS

Digital Systems Engineers

Digital data handling systems analysts, logical designers, digital circuit designers, and automatic design specialists to analyze, define, design, implement and test computer controlled digital data handling systems. Engineering, Math or Physics degree required.

Integration & Test Engineers

Responsible for definition, design, and implementation of special analog and digital test equipment. Familiar with state-of-the-art (both in test equipment and in test techniques) and in writing equipment specifications and test procedures.

Systems Engineers

Experienced in Aerospace Support Systems Engineering, including systems requirements analysis, test and checkout system philosophy, and test methodology. Duties include work on system design of automatic checkout equipment employing tape-sequenced and digital computer control media, and data processing and test evaluation. Capable of ground support systems program management and planning, technical and administrative project control, advanced system proposals, data management, and test equipment preliminary design. Ground support systems include unit test, integrated system test, launch control, spacecraft simulation, and ground station communication and command-control equipment. BSEE or MSEE with 3 years' applicable experience.

Analog System Design Engineers

Participate in the conceptual design, system mechanization, and equipment definition of analog ground equipment for the following systems: RF, Control, Inertial Guidance, Electric Power, Ordnance and FM Telemetry. Will prepare system block diagrams and specifications and support proposal operations and participate in the system test of prototype equipment.

Electrical Engineers

Duties will include performance of integration and testing of spacecraft electronic systems, performance of environmental qualification and acceptance tests, and launch site and launch stand operations. Will participate in test planning and preparation of test specifications and procedures. BSEE with 3 years' applicable experience.

Analog Equipment Design Engineers

Participate in the mechanization and circuit design of analog ground equipment. Will support the preparation of design documentation including drawings, specifications, and test procedures, as well as support model shop fabrication and test of prototype equipment.

ANALOG-HYBRID COMPUTATION

Analog-Hybrid Computer Programmers

Perform flow charting and programming of both analog and digital computers in a hybrid computer facility. Will include simulation set-up, validity checks, computer operation and data acquisition on a variety of interesting programs.

ELECTRIC SPACE POWER

MHD Liquid Metal Specialists

Scientists and engineers with an advanced degree and strong background in fluid dynamics and experienced in liquid metal technology for power conversion using MHD.

Senior Circuit Design Engineers

Design spacecraft power conditioning equipment. Familiar with design approach selection and circuit analysis, reliability techniques, parametric studies, and microelectronics. MSEE with 5 years' experience preferred.

Power Systems Engineers

Develop advanced electric power system designs for space and underwater programs. Recent comprehensive experience in power system design and analysis required. Project management and proposal experience an asset.

Solar Power Engineers

Engineers or physicists to design photovoltaic power sources and systems for space programs. Experience with solar array design, manufacture and testing required.

Electrochemists

Design batteries for missile and spacecraft. Degree in Physics, Chemistry, or Physical Chemistry with experience in design and application of silver-cadmium, silver-zinc, nickel-cadmium or other alkaline batteries required.

Battery Systems Engineers

Study, design, and test battery power systems for spacecraft. Degree in Physics, Electronics, or Electrochemistry, plus experience in electronic power system equipment, test equipment design and development required.

ELECTRONIC DEVICES

Parts Application Specialists

Creative engineers at all levels for research into new devices and their application for advanced space electronic systems and telemetry, computers, guidance and power systems. Background in device development or circuit design using integrated circuits, MOS, FET's, microelectronics or other electronic devices desirable.

RADAR & SONAR SYSTEMS

Circuit Design Engineers

Perform design, development, and evaluation of transistorized analog and digital circuitry for advanced radar, sonar, and laser systems.

Statistical Communications Analysts

Perform studies in areas of detection, prediction, filtering, information theory, adaptive techniques, pattern recognition and stochastic systems. Advanced degree required.

Systems Analysis and Design Engineers

Perform analysis and design of advanced sensor systems inclusive of radar, sonar, laser, and IR devices.

Control System Design Engineers

Perform design and evaluation of control loops of advanced radar and sonar systems.

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GUIDANCE & CONTROLS

Control Systems Analysts

Conduct synthesis, design, and analysis of attitude control systems for ballistic missiles and manned and unmanned spacecraft. MS or PhD required.

Control Systems Engineers

Perform control system synthesis design and subsystem program planning and control. MS or PhD required.

Electromechanical Engineers

Design, develop, test, and evaluate electromechanical drives, servo systems and control components for use in manned and unmanned spacecraft.

Guidance System Analysts

Experienced in the development and analysis of guidance techniques. Background in one of the following areas: astrodynamics numerical analysis, measurements and information theory, modern control theory, data filtering techniques. Will direct or perform: guidance equation formulation and performance analysis for space or advanced ballistic vehicle systems; development of orbital and powered flight trajectory estimation techniques using modern control and information theory for advanced space navigation systems.

Targeting Program Engineers experienced in system coordination and capable in digital computation methods. Provide engineering direction for the maintenance and evolution of ICBM guidance targeting programs for large-scale computers.

Senior Guidance System Engineers

Experienced in study management. Will conduct guidance system analysis and synthesis studies at feasibility and preliminary design levels including proposal writing, program plan generation, and budget and schedule management.

Fluid Controls Engineers

Analyze, design, and develop hydraulic and pneumatic systems for aerospace reaction thrust systems and thrust vector controls.

Guidance Test Engineers

Experienced in guidance systems testing (in-plant or field) including test planning, performance, and data evaluation. Will design and manage test programs and determine guidance system test requirements, test equipment requirements, and test data evaluation methods for space vehicles and advanced ballistic missile guidance systems, including LEM strapped-down inertial guidance and Apollo systems.

Test Analysts capable of detailed accuracy evaluation of performance from factors and/or in-flight test data. Will develop digital computer programs for processing of data recordings from test equipment, flight telemetry and flight tracking systems, including data filtering, spectral analysis, data blending, and error model fitting.

Guidance System Synthesists

Senior engineers with broad guidance equipment design and development experience. Will develop equipment requirements and creatively synthesize advanced systems, including inertial (strapped-down and gimbaled) sensors and optical, IR, and radar sensors.

Technical Specialists with experience and strong analytical capabilities in one or more of the following areas: electromechanical, electronic, mechanical/thermal aspects of guidance instruments, measurement systems and associated electronics.

Navigation Analysts

Apply modern filtering techniques to orbit determination and powered flight trajectory estimation and analyze accuracy attainable with various sensor combinations. MS or PhD required.

Guidance System Analysts

Apply modern control theory to the writing and analyzing of guidance equations which will be programmed for real-time guidance computers as well as analyze guidance system requirements, perform tradeoff studies, and optimize and determine performance. MS or PhD required.

Guidance Simulation Designers

Develop simulations of guidance systems and equations, perform error analyses, and analyze system performance. MS or equivalent required.

Guidance System Configuration Designers

Apply modern control and statistical estimation (particularly Kalman filtering) theory to preliminary design, including detailed mission accuracy evaluations, propulsion requirements, and success probabilities. MS or PhD required.

Electronic Design Engineers

Perform design, development, analysis, and evaluation of transistorized and microelectronic analog and digital circuitry for advanced guidance and navigation systems and control systems including strapdown, attitude, and heading references and gyrocompasses. Requires 3 to 5 years' applicable hardware experience.

Inertial System Design Engineers

Perform design, development, analysis and evaluation of inertial guidance and navigation systems including strapdown, attitude, and heading references and gyrocompasses. Requires 3 to 5 years' applicable hardware experience.

Electronic Engineers

Design and develop solid state circuitry for electro-optical systems. Background in any of the following areas desirable: D.C. and A.C. amplifiers, modulators, phase detectors, analog and digital servo circuits, low noise preamplifiers, image tube deflection and signal processing circuitry.

Electro-Optical Systems Analysts

Perform synthesis, analysis, design, and evaluation of electro-optical sensor systems and image processing systems in the ultraviolet, visible, and infrared regions. Background in any of the following areas desirable: Analysis of S/N, accuracy acquisition statistics, etc., for earth sensors, star trackers, sun sensors, radiometric and spectroradiometric instruments, etc: analysis of photographic and electronic image formation and processing, IMC techniques, signal processing and correlation techniques, modulation transfer function analysis, etc. BS with applicable experience or advanced degree in Physics or EE.

Electro-Optical System Development Engineers

Design, development, test, and evaluate sensor systems and electronic or photographic image processing equipment. Background in any of the following areas desirable: visual and IR detection and tracking, earth sensors, star trackers, sun sensors, photographic and electronic image processing, and IMC equipment, and the general application of optical components and detectors. BS with experience or advanced degree in Physics or EE.

SPACECRAFT HEAT TRANSFER

Thermal Control Design Engineers

Experienced in heat transfer and thermodynamic analysis as applied to studies, design, and development of thermal control systems for manned and unmanned spacecraft. Position includes performance of system trade-off, coordination to define subsystem interfaces, and establishment of design and test requirements.

Thermal Specification Engineers

Experienced in preparation, review, and evaluation of specifications and interface documentation related to spacecraft thermal control systems.

Instrumentation Engineers

Select and specify instrumentation for spacecraft and atmospheric entry vehicle ground flight tests. Should be familiar with latest sensors and techniques for measurement of temperature, low pressure, heat flux, and associated aero/thermo effects.

Thermal Test Engineers

Conduct thermal vacuum and simulation tests of spacecraft models and components. Must have strong thermal instrumentation background and test experience.

THE LESSONS OF VIETNAM

This Fifth Annual Dept. of Defense issue examines what the harsh combat environment of Vietnam is teaching the U.S. about the application of advanced technology to tactical warfare. Reported with full DOD cooperation from the battlefields of Southeast Asia, from military development commands in the U.S. and from industry itself, it focuses particular attention on those problems yet to be solved.

Missiles and Rockets Volume 18 Number 13 March 28, 1966

SECTION I

REPORT FROM VIETNAM

by William J. Coughlin and Michael Getler

SAIGON—With the application of advanced technology to the tough problems of limited war, United States forces in Vietnam are beginning to write a new chapter in the long history of tactical warfare.

Unlike the Korean war, an orthodox conflict fought with little innovation, the Vietnam clash is seen by military leaders as an arena in which experimentation may set the pattern for a type of war likely to confront the U.S. for years to come.

From the darting helicopters of the First Air Cavalry (Airmobile) to the infrared cameras of low-flying Air Force reconnaissance jets, hardware and tactics are being developed which will change the course of the war in Vietnam faster than many today realize.

As one U.S. military man puts it: "To fight a guerrilla, you don't become another guerrilla. That's what he wants. Instead, you use advanced technology on him."

There are, of course, many problems still to be solved. The miserable, slogging job of the Army and Marine infantryman is as exhausting and hazardous in Vietnam as it would be anywhere in the world. But military leaders here are aware that new technology already promises solutions to some of the combat infantry's most difficult problems.

As might be expected in a land of rugged highlands, tropical rainforests and flooding rice paddies, the toughest problem of all is to find an elusive enemy in his own environment.

But, increasingly, he is being found and, when found, more than matched in combat by the most professional military force the U.S. has ever put in the field. Those who say the U.S. cannot win a land war in Asia have not watched this force in action.

New dimensions—Only in the past few months has the U.S. taken the steps which bring the Vietnam troop involvement up to the scale of that in Korea. But already there are important differences between this war and the Korean conflict:

- Use of helicopters to move infantry and artillery swiftly across the chessboard of a combat zone is surprising and bewildering the enemy, no matter how great his competence in the environment.
- New command and control techniques are solving the long-standing Army-Air Force feud over close air support. The Army combat soldier in Vietnam is quick to acknowledge that the Air Force is providing him with swift-reaction air cover that in Korea existed only for the Marines.
- Army aviation itself is coming into its own. The Mohawk, Caribou and a variety of other craft, particularly

helicopters, are providing the Army with logistic support, reconnaissance and battlefield transportation previously unknown.

- Although industry hardware often is cited as too complex for the combat environment, it nevertheless is performing at a level of reliability unknown a decade ago.

None of this should be taken to mean that the war is won or that long, costly fighting is not still ahead. But as the more sophisticated U.S. soldier increasingly takes over the combat job in operations independent of the South Vietnamese (a buildup that may see U.S. forces here increase from 235,000 to 400,000 within the year), new technology can come into its own in counterinsurgency.

Combat leaders of all services have a firm grasp of the potential application of advanced technology and have established the management structure which will assure its most efficient application.

Not so's—Three general misconceptions about the war in Vietnam are significant to industry's application of its advanced know-how:

- That the Viet Cong is a scattered guerrilla army, operating with no strong central direction. The fact is that the V.C. is a tightly knit force, with strong command and control to all levels, and highly schooled in both its own tactics and those of U.S. forces.
- That the Vietnam war is being fought in a single tropical environment. It is not. Vietnam, a long, skinny country about the length of California and half as wide, offers almost as many varieties of terrain as California itself—ranging from muddy rice paddies to humid tropical forests and cool central highlands. The problem for equipment design is apparent.
- That Vietnam is primarily a ground war. In truth, tactical air power for the first time is proving tremendously effective against a guerrilla army; far more Viet Cong casualties to date are a result of air action than ground action. This is swinging the balance in the ground war.

Ground rules pose a problem—Industry must also realize that success in Vietnam, or elsewhere, may depend on the design of weapons which are compatible with ground rules imposed on the military by national policy.

This is not a small point if it is assumed that continuation of the war in Vietnam and the prospect of putting down wars of "national liberation" elsewhere in the world always will be accompanied by very careful restrictions on a U.S. military force which can—if the word is given—wreak catastrophic destruction.

In a war where attacking aircraft may be limited by Washington to one pass or one strike, it is highly important to be able to destroy a target with non-nuclear ordnance without having to come back the next day.

The list of Administration-imposed ground rules in Vietnam is long. It presents, in fact, one of the major difficulties in meaningful combat operational analysis.

Air strikes called in to support Vietnamese or joint U.S./Vietnamese ground action must go through Army of the Republic of Vietnam (ARVN) clearance channels. Though this is done as rapidly as possible, it can allow the time between the request and the delivery of ordnance by planes already airborne to reach 30 min. or more.

While this procedure may have saved a questionable target or two from an air strike, it has probably resulted more often than not in failure to hit a fleeting Viet Cong target.

Ability to strike within 5 to 10 min. of a verified spotting is highly desirable. This goal has been reached on occasion in strike requests for immediate support of U.S. troops in danger, where there is no requirement for ARVN approval.

Rules on use of air-to-air missiles in combat with enemy aircraft have also grown very restrictive, requiring positive identification before launch of a missile in order to avoid shooting down of one U.S. aircraft by another. Such a mishap is believed to have happened last year in a scrap between North Vietnamese MIG's and Navy F-4B's equipped with *Sidewinder* missiles.

The result of that action and the implications it holds for air-to-air missile design and deployment are far-reaching. It also has made U.S. pilots more conscious of a need for cannon, something left off the principal Air Force and Navy air-superiority fighter in the inventory, the F-4B and C. These aircraft have been fitted with 20-mm cannon pods carried externally. Pods, however, inspire considerably less confidence among pilots than 20-mm's which are an integral part of the aircraft. This is due to alignment problems and increased drag effects.

Buffer zones set up inside North Vietnam near the Chinese border are a hedge against an inadvertant sortie across the border, but they also provide a base sanctuary for many North Vietnamese MIG fighters.

Despite the ground rules and the environment, the collective impact of the equipment, the revolution in tactics and the taste of advanced technology that already has penetrated the Vietnamese jungles adds up to a firm realization on the part of many field commanders that successful combat can be waged by U.S. forces on any terrain in Asia.

But this should not obscure the fact that the equipment presently in the hands of U.S. forces, with few exceptions, does not reflect the level of available technology and design competence which resides in the U.S.

It also should not be overlooked that this technology did not evolve overnight, that it has been available for several years, and so, too, have been the signs of war in Southeast Asia.

In a material sense, weapons such as the M-16 automatic rifle, the M-79 40-mm grenade launcher, and the Claymore anti-personnel mine have also become "heros" of the war. They are especially well suited to it.

There are, of course, scores of others that are being used with extraordinary skill here, though they were not originally designed for this environment or to be used against the type of targets found here. The point, however, is not that they have been modified, jury-rigged, or otherwise manipulated into performing a new job, but that with equipment properly designed for this type of warfare from the outset, the job can be done much better.

The key to future effectiveness lies in a concentrated effort to design new equipment for this type of war.

RECONNAISSANCE

Detection of the enemy remains the biggest headache—both in terms of distinguishing him from his fellow Vietnamese and of locating him when assembled as part of a combat unit in the jungles and rice paddies.

The most frequently heard comment here goes like this: "Give me a black box that can tell Charlie (the Viet Cong) from another Vietnamese and I will win the war for you tomorrow."

The job is about as easy as developing a detector which will distinguish Democrats from Republicans, but some of the solutions suggested have been ingenious. They range from marker-dye capsules which stain the feet of those out of a village after curfew to use of ballistic criminology techniques to detect gunpowder traces on hands which have fired a weapon. This remains a wide-open field for further research.

If detection of Charlie the terrorist, who may be a farmer by day and a V.C. by night, is a problem, so is that of finding Charlie the jungle fighter as he burrows into vast tunnel complexes or pads silently along under the protection of a thick rainforest canopy 250 ft. above his head—a canopy which not only hides him but sets off many U.S. air-dropped weapons before they can penetrate to his ground level.

The requirement is for *real-time* day/night/all-weather surveillance of the enemy, transmitted rapidly to an attack force, so that the enemy can be denied his ability to move without retaliation.

Despite the use of airborne infrared and side-looking reconnaissance radars (SLAR) in Vietnam, top-level officers are not yet satisfied with the results.

Penetrating foliage—IR photographs at night have been successful in detecting the many small cooking fires of large groups under jungle canopy, even with V.C. techniques to dissipate the radiation from the fires.

However, in some of the double- and triple-canopy jungle in Vietnam, IR sensors will not receive the highly attenuated radiations emanating from the jungle floor. The growth in the three-canopy jungle in the III Corps area, located north of Saigon and south of the central highlands, is among the densest in the world. Military experts doubt that anything can really penetrate it.

The answer to this problem may come through remotely located ground sensors broadcasting either continuously or at programmed times, via either clandestine RF antennas or strong IR sources.

Sources here report that some of the lightweight sensors developed in the *Apollo* lunar-landing program may have application in this role. These are small enough to be concealed in the bark of trees so that, undetected, they can monitor and report on movements along a trail or highway.

IR has been less successful where smaller groups are involved and careful intelligence analysis is required to avoid hitting the wrong target.

Airplane problems—Aircraft currently carrying IR equipment in Vietnam, such as the AF/Navy RF-4 and

Troops from the First Infantry Div., in typical Vietnam terrain, poise before hitting Viet Cong sniper position.

Extent of Viet Cong camouflage efforts can be seen in this Air Force aerial photo made by an RF-101 aircraft. Several trucks are hidden beside road, waiting for night to fall before moving.

Surprised Viet Cong at training camp are caught by RF-101 in photo sweep.

the Army's OV-1 Mohawk, present another area of current evaluation. Cockpit read-out of IR systems is not quite real-time. Whereas a few minutes' delay may not mean much for an aircraft flying at 120 knots, such as the Mohawk, it could mean a great deal with high-speed aircraft such as the RF-4. R&D specialists here admit that "we may be paying too much for this capability in the RF-4." Evaluation is continuing.

Despite current shortcomings. R&D specialists see good short-range pay-offs coming with IR reconnaissance now that urgency and attention have been focused on the problem. Efforts are directed toward improved sensitivities, more rapid scan rates, better resolution, improved analysis, and signature file collection.

In the SLAR area, specialists see a potentially better pay-off than exists with IR, especially for high-power penetration of dense canopy and camouflage. While SLAR recon is now said to be effective in finding relatively large targets such as industrial plants, its ability to resolve down to much smaller items is still limited. The requirement for the SLAR aircraft to fly at low altitudes for mapping has also increased aircraft vulnerability—and, of course, alerts the enemy.

Other new requirements for airborne detectors include metal detectors possibly based upon the Navy's magnetic anomaly detection devices for anti-submarine warfare, which could be used to effectively locate the enemy's stockpiles of mines and armaments. There also is a need for the capability to detect emplaced mines from the air.

ORDNANCE

Use of conventional air-delivered ordnance for the first time in 15 years has shown that new development is badly needed in several areas. In some instances, weapons which have been off-the-shelf items need to be improved substantially; in other areas there is no weapon in the inventory to do the job.

Principal problem has been with bomb fuzes. Pilots say there have simply been too many duds dropped in Vietnam. What is worse, the V.C. make good use of unexploded U.S. bombs, turning their innards into mines used against GI's.

Reliability, particularly with bombs armed with variable time (VT) fuzes, appears to be the major problem. Bombs either are not going off or are exploding off the jungle canopy too frequently.

What is needed, say field specialists, is a two-pronged crash program to improve the reliability of existing stocks to levels at least as good as those achieved in Korea, and to develop far more flexible fuzing arrangements.

Ultimately, the need may be a universal-type fuze with a capability for pilot mode-selection within the cockpit. The three distinct terrain types in Vietnam dictate different types of fuzing arrangements, as do requirements for hitting hard-point targets or applying anti-personnel ordnance.

Bombs delivered against personnel or light structures in the soggy Delta regions of the Mekong river need very delicate, instantaneous fuzes which will distribute all their energy before they get into the muck of a rice paddy. Heavy weapons intended to collapse bunkers or hard targets through a canopy must be provided with reliable delays to get them through the canopy and the target surface before exploding. Anti-personnel weapons used in the same environment must have variable delays sensitive enough to get through the canopy and explode slightly above ground.

Because of the frequency with which U.S. aircraft are diverted from one mission to another, a pilot may not know until shortly before he rolls into his strike whether he will be attempting to kill V.C. in open country, blast them out of a bunker, reach them through heavy jungle canopy or hit them in the soft mud of a rice paddy. In these circumstances, a universal fuzing system is considered essential.

Broad needs—The spectrum of requirements for VT fuzes spans delays from microseconds to perhaps days.

The latter would be needed for improved aerial mining, something which is high on the list of weapons for area denial. Top-level AF officers say that use of the small CBU (cluster bomb unit) bomblets already developed could easily be expanded for use as aerial mines to be dropped along known enemy infiltration routes and trails. They would be equipped with delayed but highly sensitive fuzes. These, in effect, would carry out the all-weather bombing mission when weather prevents aircraft from picking out moving targets.

The CBU bomblet being used in Vietnam is employed with considerable lethality, though it, too, has suffered at the hands of fuzing problems off the canopy. One solution appears to be imparting spin to these bombs at a programmed rate. When the bomblet hits the canopy, the slowing of the spin rate actuates the arming system, thereby preventing premature burst.

Bomblets are being carried by B-52's at very high altitude and by fighter aircraft at low altitude. The weapon, together with napalm and 750-lb. bomb B-52 raids, is high on the list of ordnance that V.C. prisoners continuously refer to as terrorizing. A single B-52 can carry thousands of these bomblets; they are designed in their

Air Force F-105 (upper left), one of a flight of four, moves in on bridge target in North Vietnam. Ordnance used in the attack included 750-lb. bombs, 2.75-in. rockets and 20-mm cannon. Smoke rises after strike by aircraft that made a previous pass.

anti-personnel role to strike the ground and bounce a few feet in the air before exploding at shoulder height.

Pilots dropping CBU's from low altitude also report their effectiveness as an anti-personnel weapon, but are concerned about the dispensing aircraft's vulnerability at the low levels required for accuracy. Another problem is premature fuzing of bomblets dropped in clusters from low level. Air Force pilots feel the CBU should be further developed so that it could be delivered accurately from higher altitudes by fighter and light attack aircraft, as an area-type anti-personnel weapon, possibly using rocket propulsion.

Duds have also been experienced with bomblets, and these can prove extremely hazardous to U.S. troops moving through an area recently saturated.

Air Force and Navy aviators of all ranks are calling for better general-purpose bombs of lighter weight and more efficient energy dispersal.

Such an effort, together with the work needed in fuzing, would greatly increase the effective mix of weapons that could be carried by a single aircraft and the numbers of missions that could then be performed.

Second looks—Experience in Vietnam also indicates that trade-offs are involved in responding to immediate strike requests, and that success of a strike depends on the decisions as to when an aircraft arrives on scene and its ordnance configuration.

Most aircraft now in Vietnam are carrying far less ordnance weight than they were initially designed for. This represents only in part the switch from a carrier of tactical nuclear weapons to one of conventional ordnance. The key factor is the decision on getting to the target fast with a light load or later with a heavier one. The option taken in Vietnam is to get there fast. Obviously, lighter-weight weapons with better destructive qualities would make this conclusion more effective.

This also is causing a re-evaluation of the specifications for future attack aircraft. Planes designed to carry between 6,000 and 10,000 lbs. of ordnance are actually averaging loads between 2,000 and 3,000 lbs. The real reasons why this is taking place should be honestly pinpointed prior to development of follow-on aircraft.

Use of low-level-release, retarded-type bombs, such as the Navy-developed Snakeye, has proven highly successful in Vietnam, even against heavily defended surface-to-air missile (SAM) sites. The retardation system has enabled attacking aircraft, once they get through ground fire, to deliver ordnance very accurately and get away without being subjected to the blast from the bomb. Aviators call for more drogue-type ordnance, with heavier bombs, allowing low-angle delivery to the target.

It is in the approach to targets of this type that Air Force and Navy pilots feel least protected. The inventory includes no truly effective high-fire-power, wide-dispersal flak suppression weapon that can be applied from high altitude and with some stand-off range.

MISSILES

In operation, U.S. missiles in Vietnam have lived up to expectation reasonably well, with the possible exception of the *Shrike* anti-radiation missile.

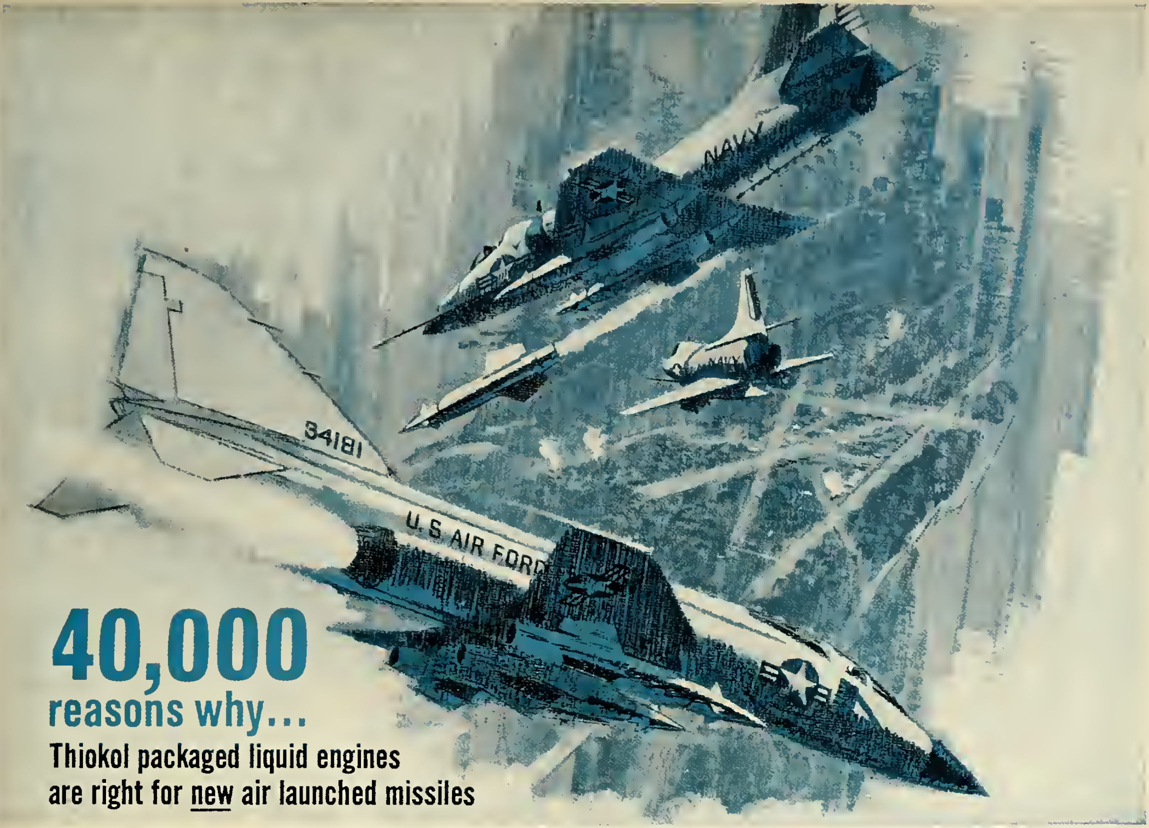
The *Bullpup*, after an early period during which the lighter-weight 250-lb. warhead was found to be ineffective, has performed well with the heavier 750-lb. and 1,000-lb. warheads against bridges and other hard-point targets which are not heavily defended. It is not optimum for runs against well-defended targets because its radio command guidance system requires the pilot to remain on the target vector for too long a period. Its low approach also makes it vulnerable to explosion by hitting tree tops.

Use of *Shrike* is generally thought to have been ineffective. However, one of the problems in assessing its performance when used as a quick response to SAM radars is the difficulty of determining whether the missile actually hit the target or the enemy turned off the radar.

Sidewinder and *Sparrow* have had little opportunity to be exercised, though *Sidewinder* is credited with downing at least two MIG's (and probably the one F-4B).

The Navy-developed *Zuni* and 2.75-in. rockets have also been used effectively in Vietnam, the latter by all three services. Demand for the 2.75 with the new fragmentation head and instantaneous fuze has been so high that production rates are being upped to 800,000 per month. Because of the unexpected use by helicopters and the high usage rate by aircraft, the 2.75 is one of the weapons admittedly in short supply here.

Disenchantments—Military planners viewing operation of U.S. air-to-ground guided missile systems in Vietnam have had an eye-opening experience—most of it unpleasant. In fact, what is most startling about U.S. mis-



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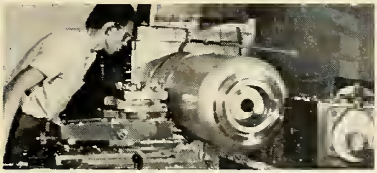

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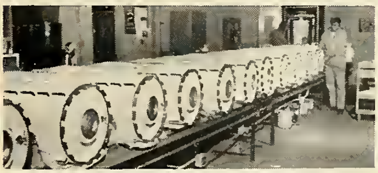

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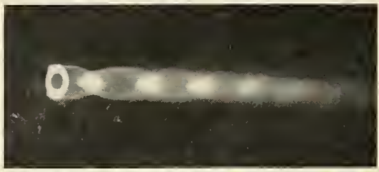

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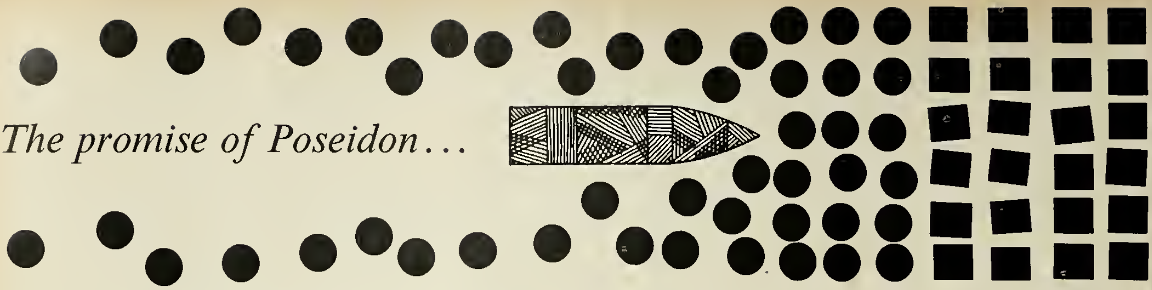

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Compared to ballistic missiles now deployed, Poseidon is a conceptual giant. It promises to be a deterrent force unequalled in its ability to penetrate hostile defenses. Now in its early stages, this long duration program offers engineers and scientists an opportunity to meet problems never before encountered in the development of a ballistic missile. Right now, broad new concepts are urgently needed in a variety of fields – thrust vector control, nuclear physics, nuclear weapons effects, structures, metallurgy, gas dynamics, systems and operations analysis, automatic test equipment, surface support equipment. If you would like to help turn the promise of Poseidon into reality, send your resume to Lockheed today. Write: Mr. K. R. Kiddoo, Professional Employment Manager, P. O. Box 504, Sunnyvale, California. An equal opportunity employer.

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sile use in Vietnam is what is not seen —because it does not occur. Strikes against heavily defended targets in North Vietnam are perfectly suited to delivery of ordnance by guided missiles with terminal homing systems, launched from aircraft beyond the range of defensive missiles and guns. But no such missiles exist.

Toward the end of the Korean war, U.S. Navy scientists were experimenting with pilotless drones, flying them into the mouths of caves and tunnels and using crude on-board TV systems to guide them in. With the end of that war came the end, too, of any significant support for further development of electro-optically guided missiles able to deliver warheads without exposing carrying aircraft to heavy ground fire.

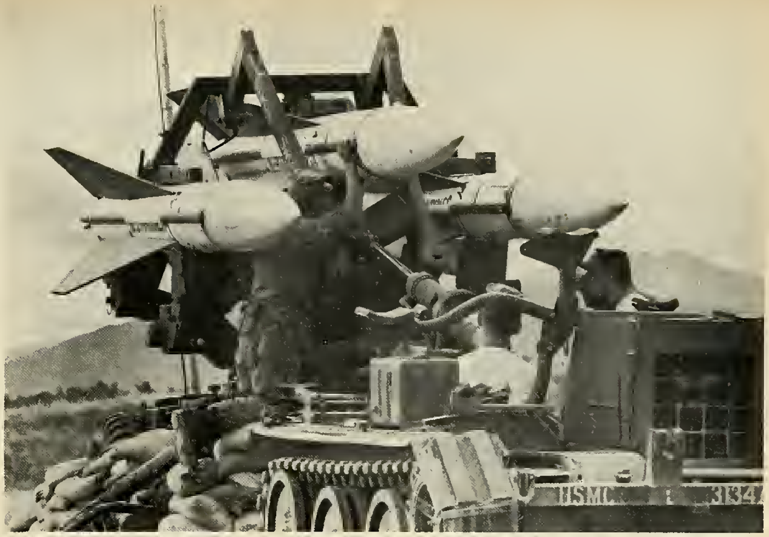
Fifteen years later, there are still no such missiles in the U.S. inventory, and there is no apparent prospect of getting any of those now in development into combat for several years.

Despite the high priorities recently given to some of these systems in the face of growing numbers of U.S. aircraft losses (M/R, Oct. 18, p. 18), it will still be 1 to 1½ years, according to informed sources here, before the first of these, *Walleye,* gets into combat. Since *Walleye* is intended for use primarily against hard but lightly defended targets, it will add no real standoff capability when employed against heavily defended targets.

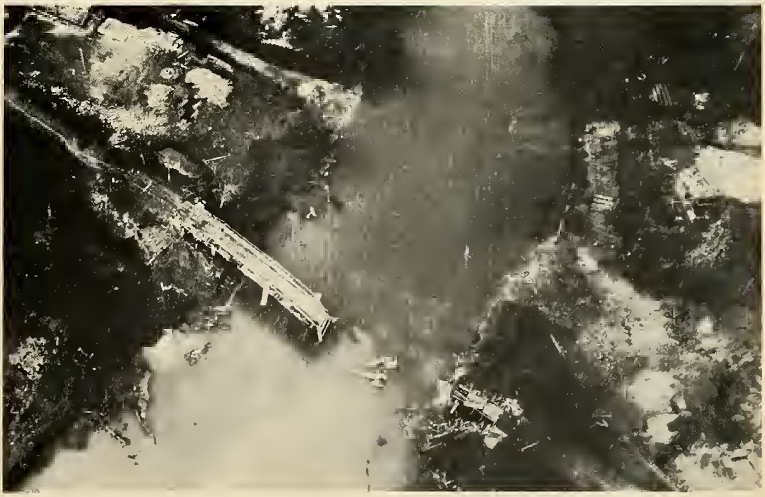
U.S. aircraft have adopted tactics which have been successful in evading most of the Soviet-built *SA-2* missiles, and have also hastily added new electronic countermeasures (ECM) equipment which provides warning of SAM radars operating in the area. Directivity of these sensors needs to be substantially improved, as does the capability for jamming these radars.

Field officers say there has been no indication thus far that the Soviets intend to introduce the more advanced *SA-3* missile into the North. The *SA-3* is a first-line Soviet weapon deployed in large numbers in the USSR. It uses a higher-frequency radar for improved target resolution and can be launched at much lower deflection angles than the *SA-2,* making it effective against low-flying aircraft. AF officers believe that introduction of the *SA-3* would not add much more of a problem. Tactical warfare specialists within DOD do not share this view.

Reluctant T's—U.S. surface- or ship-to-air defense missiles in Vietnam and in the Seventh Fleet have not been fired in combat thus far. The Marines and Army may be anxious for a combat test of the *Hawk* missile, but the Navy, according to informed sources, is probably much less anxious to put its 3-T (*Terrier, Tartar,* and *Talos*) systems to the test.



ABOVE: Hawk surface-to-air missile on station at Da Nang air base are replenished after training firing. RIGHT: RB-66 provides radar bomb control for flight of Air Force F-4C's against target in North Vietnam. BELOW: Bridge on key highway northeast of Hanoi after being knocked out by F-105 strike. Air Force claims more than 300 bridges have been destroyed and 840 others damaged in the past year.



Several hundred *Hawk* missiles are now guarding U.S. air bases in Vietnam. Six battalions are deployed around the three Marine Corps airfields in the Da Nang area.

Marine officers report that all launchers have been "on the air" since they were installed and that the missiles have scored a high percentage of simulated intercepts on returning U.S. strike aircraft which attempt to penetrate the radar defense for training. Actual target firings were held last December at Chu Lai, with each battalion firing about six missiles.

Fleet officers say the much-publicized 3-T "Get Well" program, which the Dept. of Defense says is progressing satisfactorily, has resulted in inability to transfer a fire-control rating between ships of the same class. Modifications have been tailored by individual company technical representatives, and reportediy have been largely unrecorded in master logs. This has created a large number of custom-made 3-T fire-control systems and generally useless maintenance manuals.

This appears to be one of the minor maladies. Officers are looking forward to completely new fleet air-defense missile systems which substitute command guidance for the current crop of beam-riders. Interference problems in the crowded C-band spectrum between 3-T-equipped ships operating in close proximity are said to be substantial. Navy officers say location of two-thirds of the associated electronics above-decks makes the entire system vulnerable to one successful strafing run.

Reliability problems with *Talos* are said to be substantial, and those of *Terrier* and *Tartar* not much less formidable. *Talos* is estimated by Navy officers to have only a 50-50 chance of reaching its target if it does fire—and fuzing problems are said to be cutting even further into the probability of kill.

"*Talos, Terrier* and *Tartar* together wouldn't add up to 100% on their reliability," says one Navy officer. "There are tremendous maintenance problems. It is definitely not a quick-reaction system."

Principal elements of fleet air-defense continue to be *Sparrow*- and *Sidewinder*-equipped aircraft.

CLOSE AIR SUPPORT

Close air support is generating a substantial number of new hardware requirements.

Though the Army and Air Force now are much more in tune with each other, the problems of marking front-line troops and delivering air ordnance are still being met essentially as they were in World War II and Korea. The principal refinements have come in wide-scale use of Air Force forward air controllers, flying O-1E "Birddog aircraft," for target selection, protection of "friendlies," and damage assessment; and further refinements by the Marines of ground radar and beacon-equipped aircraft.

For night operations in good weather, troops on the ground still mark their positions primarily with flare pistols, trip flares, or fires. With air-dropped flares, Air Force pilots say, ordnance can be delivered as close as 100 meters.

The Air Force is also experimenting with the Army's low-light-level TV system, using it aboard O-1E aircraft to pick out targets at night and then call in flare ships and attack aircraft. The current system, however, is said to be too bulky and bright, with a very narrow field of view.

Use of electronic systems to mark front-line troops has apparently not yet been applied to Vietnam. Lightweight (20-lb.) beacon/DME equipment for ground troops is under development; however, possible loss of such equipment to the enemy provides a major security problem.

IR systems using goggles for the pilot and IR source marking for ground troops are believed to have considerable potential for the night role in clear weather. They could also play a role in search and rescue.

Use of 2.75-in. smoke rockets fired from O-1E aircraft is also done effectively for target marking in day or night operations where the canopy is not too high to obscure the smoke. Aviators feel that if a lighter-weight rocket were developed these aircraft could carry many more than the four to six now loaded. Should improving intelligence yield information on targets under high and thick canopy, marking will have to be refined.

USMC advances—The Marines, benefiting from the basic mission relationship between air and ground forces in which air is organic at battalion level, have parlayed the close air-support system used in Korea into probably the most effective system in Vietnam—and the only one with at least some all-weather capability.

Using beacon-equipped A-4 aircraft and an improved version of the TPQ-10 radar and computer system (a replacement for the MPQ-14 used in Korea), Marines are able to bring in close-air-support in an automatic release mode at very close proximity to troops in good weather—and probably at least to inside 500 meters in bad weather.

Viet Cong tactics, wherever possible,

Air Force B-52 Strategic Air Command bomber unloads 750-lb. bombs on Viet Cong target areas. Despite the cost entailed in B-52 raids, the aircraft have been highly successful in tunnel busting and in demoralizing the Viet Cong.

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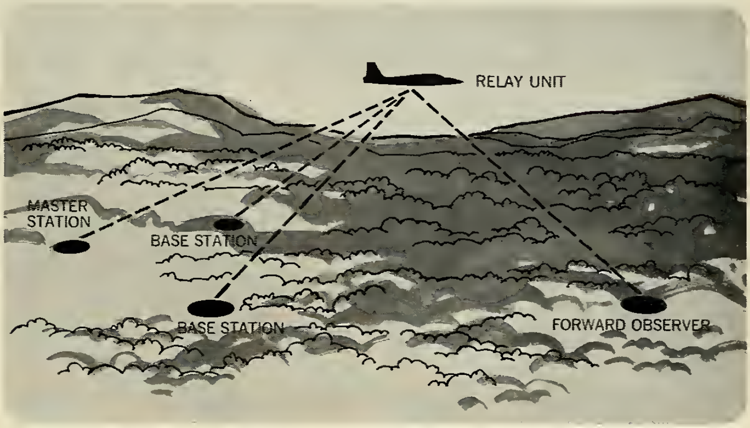

Cubic's all-weather LRSS uses electronic trilateration to locate forward elements with new speed and accuracy.

Forward observer signals location.

Having been accurately positioned, forward observers can rapidly transmit target information to fire support systems which operate in the same geodetic grid system. Your chances of achieving a one-shot kill are greatly improved, and the amount of expended ammunition is significantly reduced.

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The aircraft is flown within the base area at sufficient altitude to maintain radio line-of-sight with all ground stations. Each of the ground stations . . . including the portable packs . . . contains positioning equipment which permits automatic and continuous computation of ranges between known positions, the airborne relays, and the portable packs.

Your observers still move forward . . . but since their exact position is now determined by trilateration . . . the location of target coordinates gains in precision. Moreover, once the portable positioning pack is in place, it can be turned to stand-by and left unattended.

Mobile Master Station automatically computes data, prints positions.

A field digital computer in the Master Station then takes over. It automatically measures signals, translates them to positions, computes ranges and prints out coordinates for the forward positioning equipment.

Because the LRSS employs a man as a forward observer at the information gathering source, data fed to the battlefield commander is "filtered." The battlefield commander only gets the information he needs to take action.

The all-weather LRSS computes position over distances up to 275 kilometers — can give you target-locating data from as many as 25 forward positions. The system provides for digital transmissions between the Master Station and others, and voice communications between the Master Station and the aircraft.

Under development since 1960, the LRSS employs many of the principles that Cubic employed in the development of SECOR — the surveyor satellite. Electronic location of forward elements will prove of increasing importance — and Cubic's experience in electronic distance measurement may help you outdistance some of your problems in the field. For information, write: Chief Scientist, Cubic Corporation, Dept. E-178, San Diego, California 92123.

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ABOVE: Flight of Northrop F-5's leaves Bien Hoa AFB on strike against a Viet Cong district headquarters just 15 miles away. In Vietnam for Air Force combat evaluation, the F-5 has earned a good reputation but may be kept out of Air Force inventory by load-carrying and range limitations. (M/R photo). RIGHT: Cluster firing 2.75-in. rockets by Navy A-4 attack aircraft against a target in South Vietnam. Up to 17 of the rockets can be fired in one salvo. OPPOSITE PAGE: One of the heroes in the war in Vietnam is the Air Force forward air controller flying O-1 "Birddog" aircraft. Here one moves in at low level to assess damage after air strike.

call for very close-in fighting to get into the zone where U.S. pilots cannot safely drop ordnance without endangering their own troops.

Marines have also exercised the system with F-4 aircraft, which are not beacon-equipped, using skin track to about half the range possible with beacons. AF aircraft are also worked with the TPQ-10, even though the beacons have been removed from cockpits already crowded with electronic gear.

Marine Corps officers feel that the ground-based radar can be improved considerably, particularly in simplified field maintenance and weight reduction.

Use of microcircuit design with modular, throw-away-type replacement parts, and introduction of higher-power solid-state front ends would allow major improvements. Substantial increases in operating frequencies would provide more precise slant range and azimuth information on which to base commands for ordnance release. Errors of even a fraction of a second in radar-controlled deliveries may cause errors of 50 meters or more in ordnance dropped by high-performance jet aircraft.

Ordnance dropped by the Navy's venerable A-1 propeller-driven aircraft, flown mostly by Air Force and Vietnamese pilots for close support, is the most accurately placed of any in Vietnam. These aircraft, flying on the deck, have delivered ordnance within 50 meters of "friendlies."

Outmoded accuracy—Air Force generals see a major requirement for a system which will substantially improve the accuracy of tactical aircraft in delivering bombs against point targets. These officers feel there is too much room for human error in a system of visual delivery which still does the job essentially as it was done in World War II.

Both Army and Air Force commanders agree that close air support of ground troops has never been better, due largely to the skill of pilots and air/ground controllers in a compatible team. They also agree that the lack of a system to do the job more accurately in daylight, at night and in bad weather, is absurd.

The same requirements exist, of course, for Navy and Marine tactical aircraft.

Back in the U.S., some experimental work has been carried out to couple lasers into the inertial navigation system and computer of an F-4C aircraft for this purpose, but a better system for eliminating known variables still is very much needed.

Small-unit contact—Communications required for good close-air support have improved considerably, but there are still vestiges of earlier snafus. Initially, there was complete incompatibility between Army ground radios and Air Force equipment. Communications existed only through use of Air Force radios on the ground in the hands of the Air Liaison Officer attached to a battalion, and did not extend to the company or platoon level.

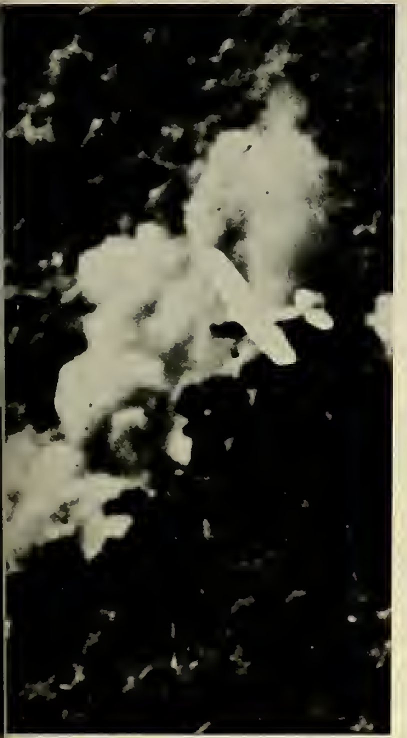
Introduction of the small, lighter-weight PRC-25 radio for platoon and company use has improved communications to the smaller units, but Air Force officers say that despite introduction of new FM equipment into both services, frequency selections do not appear always to have been properly matched to insure good communications.

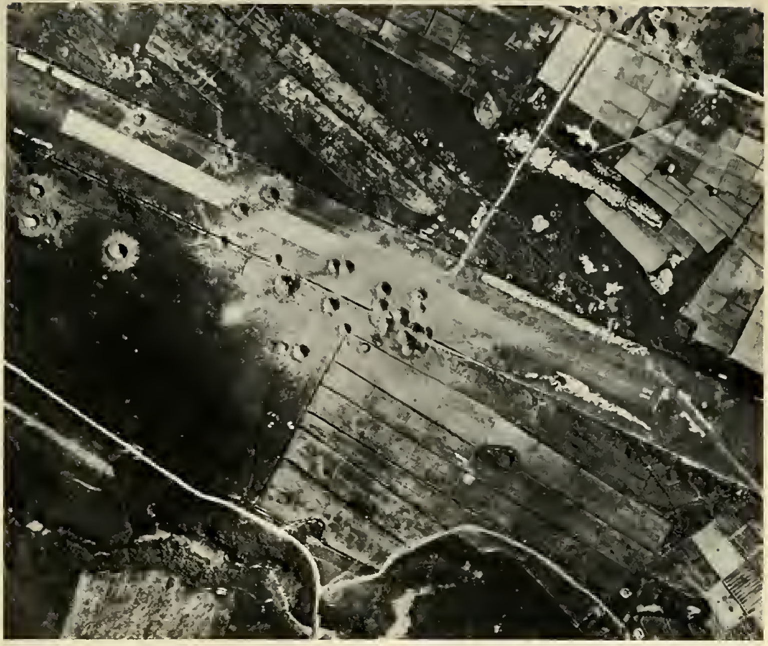
Much of the problem, however, has been solved by equipping both ground and airborne forward air controllers with radio packs which contain four radios—UHF, both AM and FM; VHF-AM and single sideband. The FAC is able to talk to both ground and air forces. An attempt to put everyone on the same frequency, even during an actual close support strike, would hopelessly jam communications.

TACTICAL AIRCRAFT

By getting 100% out of their aircraft, Air Force pilots in Vietnam are doing an excellent job of close-air support, weather permitting, though none of the aircraft they are flying was designed especially for that purpose.

The F-4 has been used very effectively, and represents the most flexible and advanced craft in service. But it is also heavily laden with electronics for





Runway at Dien Bien Phu photographed by RF-101 after first bombing pass by Air Force planes. Airfield is one of the few that are on the Administration-approved list in North Vietnam.

its air-superiority fighter role, and its overall complexity and design do not reflect what Air Force officers here would like to see in a special-purpose close-support aircraft.

Announcement by DOD that the Air Force would buy an afterburner version of the Navy's new A-7 attack plane has not been met with great enthusiasm among pilots now flying combat missions. While impressed with the craft's range and load-carrying abilities, Air Force flyers say they are concerned about the aircraft's vulnerability to ground fire due to its size, subsonic speed, and single-engine design.

Whatever shortcoming pilots may believe the A-7 has, it definitely represents at least a step away from the Air Force's tendency to buy only multi-mission tactical aircraft—and a step towards what combat pilots hope is a special-purpose goal.

There is a strong tendency in DOD to favor multi-purpose and multi-service aircraft, but there is no agreement within the ranks of the Air Force concerning the multi-mission versus special-purpose tactical aircraft. Lack of agreement has no doubt weakened the Air Force's position in challenging DOD.

Air Force operations officers in Vietnam are strongly in favor of new special-purpose craft. They state flatly that "an aircraft that is all things to all people can't cut it here." Operations officers say that "85% of the areas of the world where limited wars are likely can be covered from fields with 6,000-ft. runways." If experience in Vietnam is any teacher, they say, what is needed is a simple, easily maintained strike aircraft that can operate in hot weather from runways with maximum lengths of 6,000 ft. (and preferably from much shorter strips), with a combat radius of at least 150 miles, with a 500-knot dash capability, and a load-carrying capability reflecting what Vietnam experience indicates is optimum.

With such an aircraft, say planners, "we could cut the time to respond from the ground to strike requests to 5 to 10 minutes from the current 30 to 50 minutes. It would also cut down on the requirements for airborne combat air patrol."

Too special?—The F-5, built and successfully sold as a Military Assistance Program aircraft but now being evaluated by the U.S. Air Force in Vietnam, comes close to meeting those requirements. However, it is likely that as far as the USAF inventory is concerned the F-5 will fall victim to a charge of "too special-purpose."

The F-5 has been used effectively in the South and has now been given an extended tour so that it can work targets in the North operating from Da Nang. It has proved to be an accurate bombing platform, with good maintenance characteristics, rapid turn-around, and good availability. All of this, however, was expected. Most top-level Air Force officers say its performance "has held no surprises either way."

The critical shortcomings mentioned by those close to the evaluation are its limited range and load-carrying capabilities. "If you have targets which require lots of ordnance and you have F-4's and F-100's around, then there may be a place for the F-5," says one analyst. "The F-5, by itself, would not be the right aircraft."

The aircraft has been hampered somewhat by foreign-object damage to the engines, and jamming problems were experienced with its 20-mm cannon. Modifications which should remedy these flaws are in the works. The version being used in Vietnam does not reflect the latest improvements to the aircraft. Air Force pilots say a higher-powered engine, new two-position nose wheel, and improved air inlet doors already developed will cut by one-third the aircraft's time to target and runway requirements (now about 6,200 ft.)

Report of an evaluation team from the Rand Corp. now in Vietnam, and an Air Force report on F-5 operations are expected to be submitted within the next two months. The factors which will go into the decision whether to buy the F-5 for the USAF are extremely complex, says one civilian analyst. The most widely held feeling at this point is that it will not make it. It is felt, however, that the F-5 is still an extremely good

MAP aircraft and is apt to soon become part of the Air Forces of Thailand, Korea, Vietnam, and possibly the Philippines.

Multi-purpose—Opposition to multi-purpose craft in Vietnam is also directed in part at the new OV-10A COIN aircraft. There is widespread agreement that its use as a reconnaissance vehicle to replace the O-1, and to provide at least some armament capability to take limited-type targets in this role, is highly desirable. However, its expansion to "police-car," close-air support, and re-supply roles is not widely endorsed.

Marine Corps and Air Force officers feel that in a "police car" mission carrying a squad of armed men, the aircraft's need for a landing strip will set it up easily as a target for deception and ambush. Helicopters appear a better bet. For close-air-support and re-supply, the OV-10 is viewed as too much of a compromise to be effective.

Critics of this view among R&D specialists here say that the aircraft must be viewed in a larger perspective than the current level of fighting in Vietnam. At present levels, it admittedly would be marginal in other than the recon role. However, in phases of counterinsurgency in a highly decentralized war, where fighting is at a lower scale, its use in the hands of a skilled Air Force could possibly prevent escalation. If the Vietnam conflict drops back into the so-called Phase II of pure guerrilla warfare, then COIN could probably play a larger role.

Other needs—Special Forces officers say they would like to see technology applied to building "a truly simple aircraft that a man could learn to fly as easily as he can learn to drive a jeep." Lack of helicopter pilots or courier planes to move one or two men has hampered operations in several instances, they report.

Deployment of MIG-21 aircraft to North Vietnam has also raised concern among U.S. fighter pilots. While the F-4 is probably a higher performance aircraft, the mix of cannon and missiles on the MIG-21, in addition to its speed and handling characteristics make it a formidable foe, and U.S. pilots feel strongly that there is need for a new aircraft which would clearly provide superiority. Fighter pilots envision a Mach 3, 25,000-lb.-class fighter, made light with titanium structure and equipped with cannon as well as missile capability.

With the Air Force procuring large numbers of F-4 aircraft, and with the A-7A and OV-10A on the way, the Air Force, as in the tactical missile field, is well on its way to another Navy-supplied arsenal. Should the Navy's A-6 aircraft prove successful in pathfinding operations in the North, there could also be pressure for a number of these in the Air Force.

As in the tactical missile field, the lack of stronger Air Force participation in tactical aircraft development has tended to weaken the entire field.

LOGISTIC AIRCRAFT

In the assault transport and logistics area, the Lockheed C-130 and Fairchild-Hiller C-123 aircraft are both doing heavy work for Air Commando squadrons in an effort which already daily overshadows the Berlin airlift.

Officers expect delivery of the first of 120 modified versions of the C-123 beginning in November. The modifications will add two auxiliary jet engines, wider landing gear, and better brakes. This should eliminate short-field and single-engine limitations now imposed on this craft. The new capability should also add the equivalent of one third as many airframes to the operating force.

The C-123 has shown itself to be airworthy in the face of a very high hit ratio from ground fire. Despite its vulnerability, relatively few have been lost. However, Air Force officers say that assault transports with true V/STOL capability are badly needed. They also would like to see new cargo off-loading equipment which is good for rough terrain and can be stowed in the aircraft.

Use of the CV-2 Caribou has been highly successful in Vietnam. It is used extensively by Special Forces and cavalry combat teams for forward-area re-supply using air drop or short-field landing. The biggest complaint is that there are not enough Caribous.

Several officers interviewed were irate over the phasing out of procurement of both the Caribou and the follow-on Buffalo aircraft by DOD. Both aircraft are produced in Canada.

First Cavalry officers say the Buffalo would give them 4,000 lbs. more payload capability than the Caribou. Comparisons with helicopters for this mission still favor the CV-2 and CV-7, in terms of speed, range, payload, and ability to carry bulky loads.

On the other hand, some Army officers, viewing Air Force plane-handling abilities here, say they are willing to have the Air Force and its C-123's provide the short-field forward area re-supply.

THE GROUND WAR

New equipment requirements for ground warfare produced by experiences in Vietnam penetrate every facet of combat and its support.

Special Forces officers are generating many of the new requirements. Officers, well pleased with the performance of the M-16 rifle, say the weapon needs to be streamlined to get rid of "too many protuberances." The M-1 with a sawed-off stock has proved to be a very valuable SF weapon.

Furthermore, a good silent weapon has yet to be produced, say SF men. The ones which have been put forward don't satisfy the Army and are too heavy.

"What we need most," according to one Special Forces lieutenant colonel, "is a simple means to fix our position on the ground. Despite what the book says, over here there are damn few people who really know where they

C-123 aircraft are providing backbone of cargo and troop delivery in Vietnam, along with the four-engine C-130. For the short-field assignment, pilots are looking forward to the new version of the C-123 that will be in service this year.

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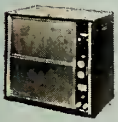

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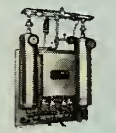

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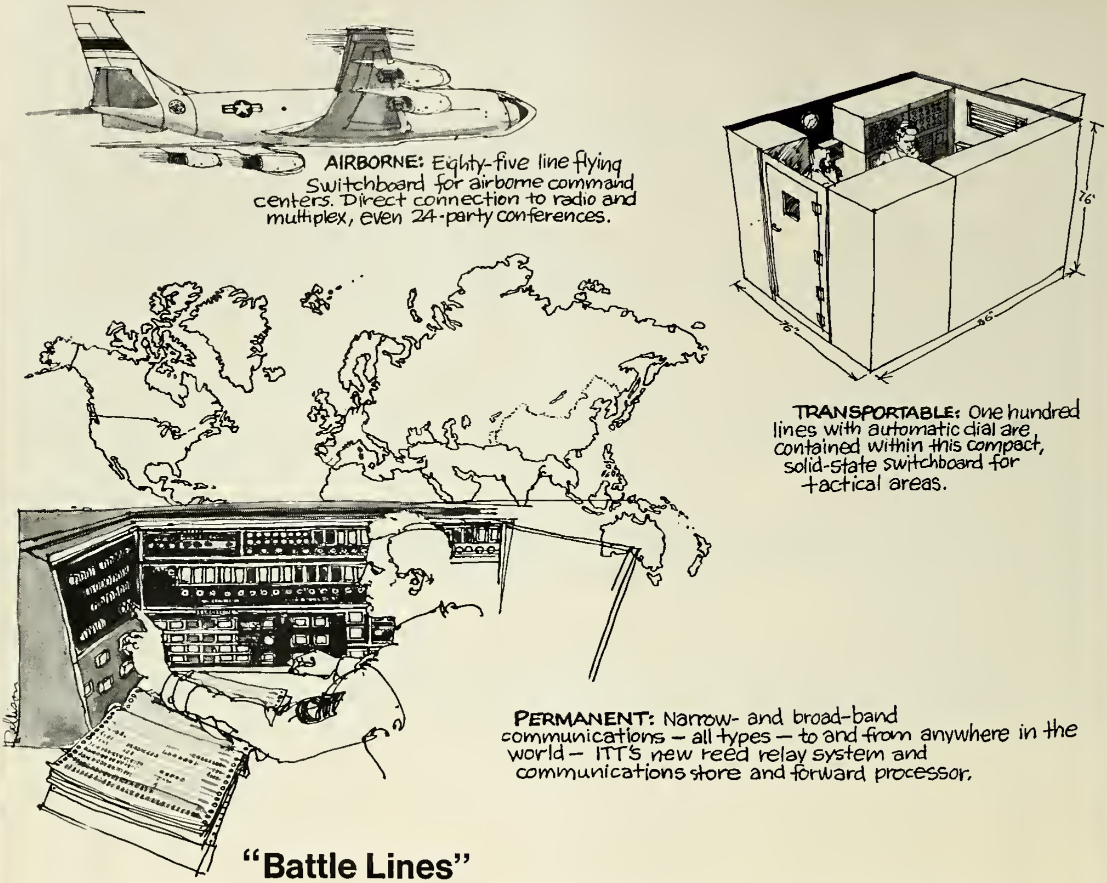

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are." Officers say tethered balloons spotted by an FAC who follows up with position indication are not satisfactory. The balloons require water and gas generators, which are bulky and noisy.

One solution suggested is some kind of inertial guidance system for ground troops which would move with them and record movement from a known point.

Special Forces operations have also focused new attention on the need for lighter-weight mortars. The old 60-mm mortar, which is light enough to be carried on small operations without vehicles, is favored, as is the newer M-79 40-mm automatic grenade launcher for engagements out to about 400 meters.

For the heavy mortar role, SF officers say even the best U.S. weapon does not compare with the 120-mm Soviet-built mortar which has showed up in Vietnam. "Anybody in the defense business who wants to make some dough," one colonel said, "ought to go to Hong Kong, buy one of those on the black market, take it home, and manufacture it!"

The point-detonating fuze on the weapon is so fast that it leaves virtually no hole in the ground. The shell is said to be perfectly designed to provide maximum fragmentation. "There doesn't seem to be one sliver that comes out of that round that is bigger than a small finger nail, and they're all deadly."

Despite years of recognized need, a rapid system for determining direction and location of enemy mortar fire has eluded the combat forces.

Also desirable would be illuminating flare rounds for both the 60- and 81-mm mortars, something which so far has proved impractical to design.

Army officers seek improvements in infantry radars, which have proved to be major generators of intelligence, to reduce operator training requirements by better display.

Anti-ambush—Requirements for new anti-ambush equipment still exist in Vietnam; however, the growing U.S. guerrilla experience has reduced the urgency somewhat.

First Infantry Division is using a new 8-barrel mortar system which shoots fragmenting M-79 grenades. Other new techniques may be in the offing, including small, lightweight units, carried by a single soldier and deployed instantly in an ambush, which salvo large numbers of small tear-gas-filled projectiles, arcing the shells around the ambushed unit.

Large-scale loss of U.S. weapons to V.C. units has also renewed interest in combustible or other unreusable containers for an assortment of weapons where it is feasible.

Tracer development also needs to be improved. The Army says it wants tracer action with its M-16 out to 1,000 yards, but that it is having trouble packaging the tracer in the ammunition.

Tracer action is also wanted in the M-5 automatic grenade launcher, which has been adapted to the Army's armed helicopter force. Tracer action with this weapon at ranges greater than the tracer burn-out range of enemy 50-cal. machine guns would give the helicopter accurate stand-off capability against ground fire.

Mines—Detection of non-metallic mines is another problem still confronting the Army. Though most officers won't say much about it, there is believed to be a quiet revolution going on in U.S. arsenals regarding new mine developments.

Better control of minefields, with control systems secure from jamming or other enemy tampering, is needed. In addition, small cluster-type mines which could use light rocket boost to get them above the surface before exploding are believed to be under study. These would not leave any crater and would leave other mines in the same place unexploded and undisclosed.

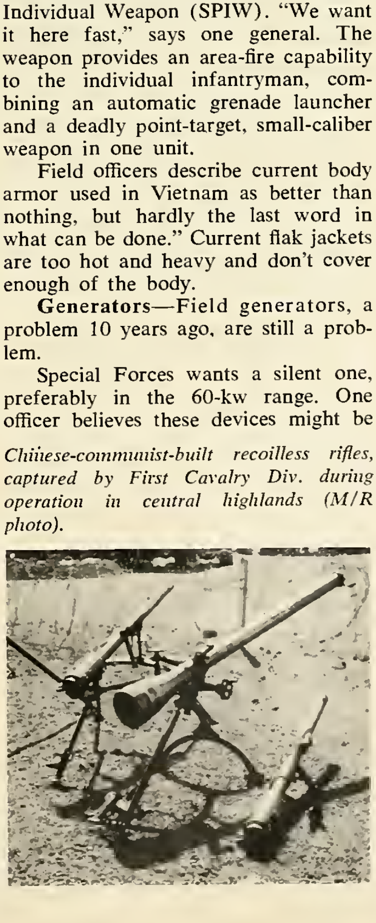
Top-level Army officers here are also pressing for rapid deployment to Vietnam of the new Special Purpose Individual Weapon (SPIW). "We want it here fast," says one general. The weapon provides an area-fire capability to the individual infantryman, combining an automatic grenade launcher and a deadly point-target, small-caliber weapon in one unit.

Field officers describe current body armor used in Vietnam as better than nothing, but hardly the last word in what can be done." Current flak jackets are too hot and heavy and don't cover enough of the body.

Generators—Field generators, a problem 10 years ago, are still a problem.

Special Forces wants a silent one, preferably in the 60-kw range. One officer believes these devices might be better designed as two separate units, so that one could be maintained while the other operated. "The tendency now is just to keep running them into the ground and you wind up with nothing," says one specialist. Generators that are kept operating over specifications, as is almost always the case, also cause harmful frequency and current oscillations.

Chinese-communist-built recoilless rifles, captured by First Cavalry Div. during operation in central highlands (M/R photo).



Air Force communications officers say that generators in the 30-150 kw range able to operate reliably unattended for 12 to 18 months are a major need for powering a variety of communications systems and aircraft navigation aids. The system should be air-transportable. Air Force officers say a 300 to 400-lb. nuclear-powered unit could easily handle the job, but note the dangers accompanying the use of nuclear powerplants in a combat zone.

The generator problems extends further upward into the very large, 3,000-kw units needed to support base camps. Army divisions arriving in Vietnam with only their organic support equipment find they must satisfy the needs of a much larger base installation. Perimeter lighting presents a big requirement for power.

Large generators of this variety are long-lead-time production items, and demands in Vietnam were not properly anticipated. The result is a widespread power problem throughout the country.

Several smaller size generators are being purchased from Japan to help with this. Again, top-level Army officers who have watched a variety of Army programs in atomic power fall short of fruition see the nuclear solution as a good one if safety against combat damage is assured.

Other posers—There are dozens of other problems to be solved for the ground forces.

Field clothing, lightweight sleeping equipment, load-carrying equipment, mosquito net trousers, anything that will lighten the load of the infantryman is a highly fertile area for new R&D. U.S. planners are taking a close look at Australian equipment and doctrine in this area. No more than a 25-lb. load is desirable for a man operating in the hot, soggy Delta region.

Base security poses new challenges. Wanted are alarm systems which are not detectable or visible to the enemy and which also provide some indication of where a perimeter is being breached.

Tunnel detection is a high-priority problem today—although some exotic solutions already are being tested. One is the use of infrared aerial photography in much the same manner as it is used to locate ancient Etruscan cities in Italy or caves in Israel.

Tunnel mapping from the ground under combat conditions has not yet yielded to technology—although experts

are optimistic about a solution. Seismic systems have been tried, but battlefield conditions make it impossible to control geophone inputs. Cavity-resonance systems appear promising, but equipment is heavy and transport problems are obvious. Differential magnetometers and gradiometer systems probably will be tried, using helicopters for transport.

There also remains a need for a method to destroy or permanently deny such tunnels to the enemy once they are found. This must be a means which can be used quickly in a combat situation and which is acceptable to world opinion as a "humane" solution—which means no poison gases. Though some of these chemical agents could deny use for periods of years, the absence of clearance to use them means combat troops must still rely on conventional explosives—and they are unable to carry enough of these. Use of Primacord-detonated CS agents in crystal form is effective for up to six months' denial.

The B-52 appears to be an effective, albeit expensive, tunnel-buster. B-52's reportedly have collapsed tunnels as deep as 60 ft., and the new tactic of double-bombing, to drive the enemy out of the tunnels and then hit him in the open, appears to be working well.

Chemistry—The chemists are not excluded in the search for new ideas. Destroying large caches of rice uncovered in combat is not an easy task. Often U.S. helicopters are committed for long periods to bring the rice, if it is polished and edible, back to refugee camps. When this is not possible, making 150 tons of rice unusable to the V.C. is a definite challenge.

Chemical warfare has also uncovered new requirements in Vietnam. Riot-control agents used in "humane" warfare need to be more properly matched to weapons systems, a problem which Army experts say is quite complex. Delivery of tear-gas grenades by hand or from low-flying aircraft in general leaves the delivering system very vulnerable. What is needed is something which would allow packaging of these agents into a round which could be delivered at ranges roughly between that of a grenade and a mortar.

Defoliation in Vietnam has had marginal success, carried out in Project Ranch-hand by a group of the most shot-at pilots in Air Force history—flying C-130's at tree-top level in formation over V.C.-controlled areas. The technique has been most successful in removing cover along the sides of canals.

Scientists say, however, that "we still don't have anything that will knock a leaf off a tree in two minutes." Much depends upon the amount of moisture deposited before or after a sweep, the type of plant, and the stage of its development. Crop destruction carried out under "Ranch-hand" has been much more successful.

COMMUNICATIONS

Communications in Vietnam do represent some improvement from those available before, and this in itself has created new problems. "Some communications are so good," says one officer, "that we have too much traffic; the nets are overcrowded, messages are too long; and we have already overloaded whatever new capacity we had."

Vietnam is unique in that at present there are no front lines—everybody is stationed in enemy territory. Military communications procedures used for decades won't work here because no one owns the ground between points where cable might be laid, or around microwave or troposcatter stations that now must be heavily protected wherever they are.

Vietnam is also unique as a country in which even the basic telephone communications system, which normally can be built upon, was no longer in existence.

Experts say this argues heavily for future development of basic telephone equipment in modular, plug-in building blocks, where installation, repair, and operation by less than highly skilled technicians can be accomplished.

Sudden awareness between services, especially the Army and Air Force, that their equipments were not designed with each other in mind has created a loud call for standardization.

Special problems—Nothing in Vietnam is easy to hook up to something else. Integrating troposcatter with tactical microwave nets, VHF systems, and others has required special-purpose buffers and a maze of custom-made signal attenuators or amplifiers to try and match widely varying db levels and transmission techniques. Even ringers for telephones operate on different cps and have proved hard to connect.

For long-range communications, wide-band troposcatter systems have been installed. These represent improvements over Korean war units, but Army officers say that weather problems still interfere and that present power levels (in the absence of complete choice of sites) need to be increased to insure against loss of signal.

Helicopters are also used extensively for communications relay in mountainous terrain, especially under combat conditions where ground troops cannot get HF antennas set up. On-station time for the helicopter is a problem, and the Army is highly interested in development of tactical communications satellites.

Use of helicopters on so large a scale has also created special problems. First Cavalry officers say commanders must have access to great numbers of units. "If a company gets diverted, a commander needs immediate access to over 65 frequencies. This creates a large security problem and requires units to carry massive code,

OPPOSITE PAGE: South Vietnamese troops prepare to board U.S. helicopters for assault in Mekong Delta region after a strike by Air Force B-52's.

U.S. troops move toward battle positions after lift by CH-47A Chinook helicopter. This transport and cargo craft has proved to be highly versatile.

call sign, and frequency information. What we really need is a small and simple voice encryption unit which will allow us to talk freely on radio. We have some coming, but they're too big."

The crowded frequency spectrum now available requires that new equipment be very precisely designed to perform as specified. The new VRC-12 family of FM radios is performing extremely well. But, as range of the system is increased, overlap is experienced and interference problems are encountered. The same trouble has been experienced with new field radios.

Small pocket-sized radios such as the PRT-4 and PRT-6 "were too good and went too far, farther than we wanted them to, and they caused interference. What we need is a reliable, short-range lower-echelon radio which covers a 500-yard range. By reliable, we mean one that goes just 500 yards, no more. Ability to precisely control this would allow a lot more frequency sharing than is now possible with so many squads. A real breakthrough is also needed in precise definition of radio channels."

Officers also say a new small squad-size radio is needed to replace the PRC-6, which is reportedly too fragile.

Crowding—Frequency crowding problems get more complex at night, especially use of single sideband teletype communications. This problem has shut off entire brigades from division headquarters.

Special Forces officers say a radio is needed to replace the 30-lb. PRC-74, which is too heavy, and the PRC-64, which is much more limited but is preferable simply because it is lighter. What is needed, they say, is a 10-lb. radio with a 15 to 20-mi. range, with a battery which is good for at least seven to eight days of heavy use.

Communications management and better command and control systems can aid the frequency problem. Highly effective centralized control of Air Force tactical fighter/bomber networks has increased the number of available channels. Nevertheless, the sheer amount of air traffic presents a continuing problem. Transport operations have been hindered by inaccessibility to HF fighter nets, and have to operate with teletype circuits which are not too secure.

Air Force communicators add other new requirements—including teletype equipment that can run at least at 100 words per minute, and a more rapid (300 to 3,000 wpm) transmission medium which will match the high-speed data-transmission equipment that has been turned out.

Heat and humidity problems, and the corresponding cooling requirements, experienced in Vietnam also demand far more extensive use of microelectronic design in future equipments.

HELICOPTERS

Operations of the U.S. First Cavalry Div. (Airmobile) in Vietnam have brought about a revolution in tactics, new lessons to be applied in the makeup of future air assault divisions, and considerable experience in new hardware needs.

The Army's selection of the Bell Helicopter Co.'s "HueyCobra" was welcomed by every echelon of that service here as fulfilling a major new requirement—for an interim armed helicopter between the currently used UH-1B and the proposed Advanced Aerial Fire Support System (AAFSS), which is still about three years away from service.

First deliveries of the Cobra are expected in mid-1967.

The craft, flying prototypes of which have been built, will more than double the speed of the currently used weapons ship. The current UH-1B cannot go faster than the troop-carrying helicopters, for which it has a suppressive fire and protective role. The new ship will also greatly increase range. In current operations, weapons ships must usually rendezvous at some forward point with troop carriers since, in many cases, they do not have the range to leave from base camp, fly their support mission, and return.

Though the Cobra will definitely be a single-mission craft, as opposed to a dual configuration as a rifle squad carrier, supporters here point out that it will require no pilot transition training, will use many common parts, and can be fitted wth slings for some lift tasks. They also say that the Cobra could serve as an excellent test bed to determine optimum weapons, radar, and sensor configuration for truly second-generation systems such as AAFSS.

When longer-range armed helicopters are available, officers say, the need for forward bases, which require additional security, can be eliminated through ability to operate from a single base camp. Current operations extending to 50 to 75 kilometers from a base could be extended to 200 kilometers, they feel.

Lessons learned—The future of air assault really depends upon advanced technology, say combat crews here, citing a need to keep maintenance hours at a low level in comparison to flight hours, and to continue to improve that ratio.

Combat situations have taught new lessons in Vietnam. The original goal of a 10-man squad in the UH-1D has been reduced to seven by the addition of gunners, crew chiefs, and some armor plate. Density-altitude problems have reportedly cut this to five.

The division uses 500-gal. drums of aviation gasoline and 250-gal. water drums to support operations. The Huey could lift these in the U.S. but it can't here. This has led to new requirements for 75 to 100-gal. rubber water bags. The larger CH-47A Chinook helicopter, widely used for secondary troop lift and cargo, can lift two of the 500-gal. drums at a time. The huge CH-54A Flying Cranes can take four at a time.

New Lycoming engines in test at Ft. Benning are expected to improve hot-weather helicopter performance.

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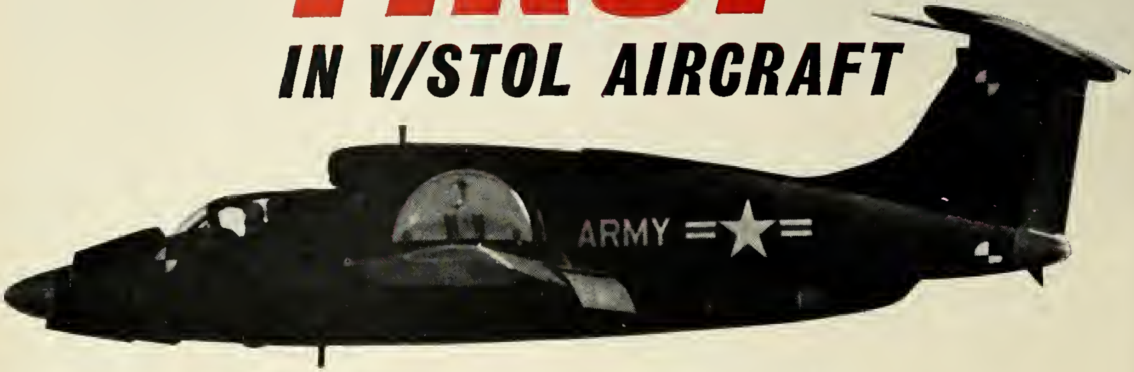
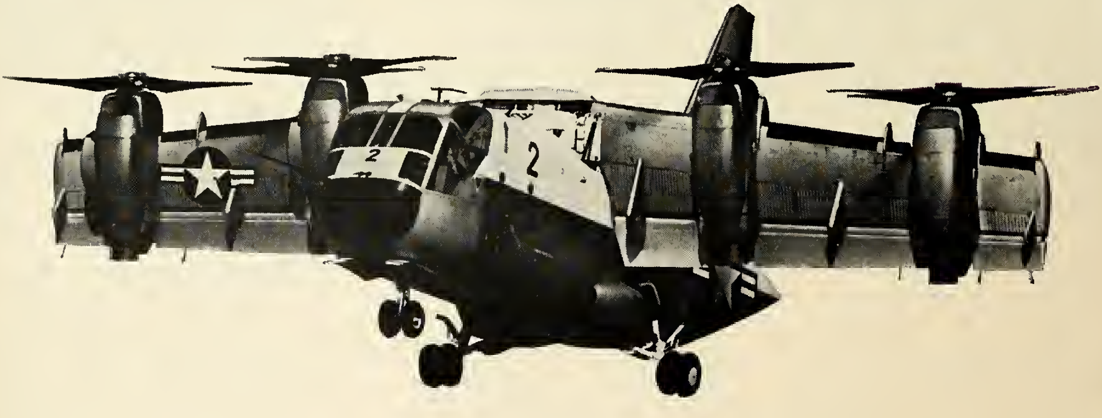


XV-5A This Vertifan aircraft, the only V/STOL which achieves vertical flight on no more power than needed for conventional jet flight, is now probing deeper into V/STOL flight research. The XV-5A has made more than 275 flights at Edwards AFB since May 1964. Nine military and government agency pilots have flown it. The XV-5A concept is adaptable to advanced V/STOL flight research, V/STOL pilot training and search and rescue missions.



XC-142A This four-engined troop-cargo transport's wing tilts up for either VTOL or STOL operation... then rotates forward for horizontal flight. Like the XV-5A, it can operate from minimum prepared sites and is technically proven in flight. Ryan and Hiller are team partners with XC-142A prime contractor LTV.

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South Vietnamese troops move toward objective in Mekong Delta after disembarking from HU-IB helicopters.

First Cavalry experiences have also turned up other new equipment needs.

Materials-handling equipment for rough terrain, possibly using air cushion principles, is needed—specifically, a fork lift that can handle 5,000-lb. loads.

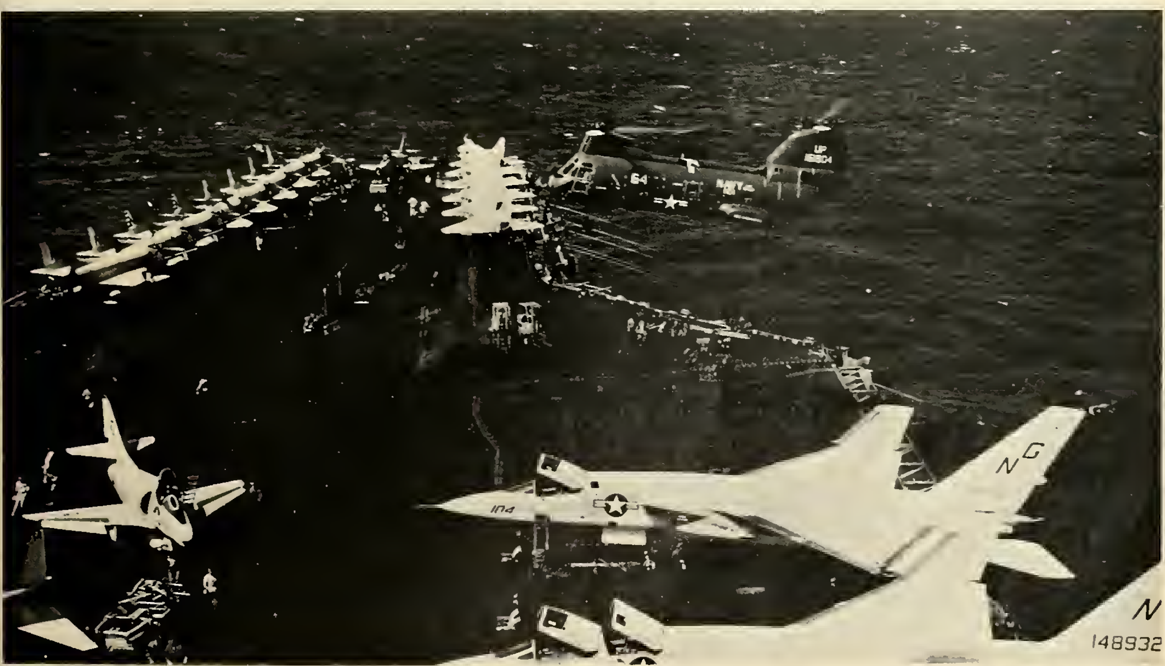
Also sought is a 300 to 400-lb. helicopter-transportable vehicle with a low foot-print pressure, able to carry 300 to 400 lbs. of equipment cross-country in support of troops once they have landed.

One major impact of the First Cavalry's operations has been development of the ability to lift heavy artillery and bring it quickly into play so the enemy can never outrun the big guns. The new M-102 105-mm howitzer is expected to arrive in Vietnam in the next few months. Its weight is about 60% of that of the standard 105-mm now transported in helicopters, and it is expected to set the pace for a new generation of lightweight artillery for this purpose.

New lightweight armor is needed. Current armored seats in helicopters weigh over 200 lbs. Commanders want protection at least from the 7.62 armor-piercing round used by the enemy, even if it is not possible to protect against the heavy 50-cal. rounds.

Commanders are also looking forward to replacement of the H-13 reciprocating engine helicopter—now used

Vertical replenishment of USS Enterprise under way off the coast of South Vietnam by H-46 helicopters from USS Sacramento. The supply technique has been greatly successful in reducing period of carrier's vulnerability (M/R photo).



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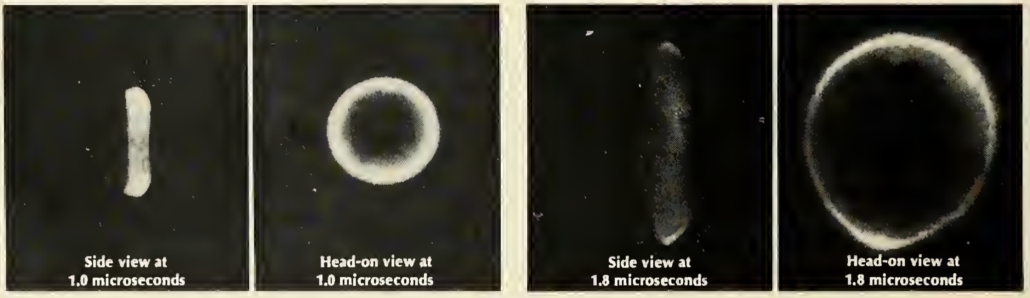

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Operation Market Time, carried out off the coast and in many waterways of Vietnam, is a search effort aimed at turning up contraband carried in many of the 50,000 sampans and junks that move through these waters (M/R photo).

for scout, liaison, and reconnaissance—with the new light observation helicopter, which will use a gas turbine, like their other choppers, thereby simplifying maintenance.

First Cavalry crews have also been innovators of new helicopter equipment such as field-expedient defoliation systems, ripple-fire tear-gas grenade launchers using empty rocket tubes, and a radio wire integration system which has more effectively linked UHF aircraft communications to command posts, and then to rear areas by microwave links. The field equipment was built into ammunition boxes.

The division has also made use of the Flying Crane fuselage sections, turning them into forward command posts and field hospitals. The 9-10-ton lift capacity crane has done excellent work in Vietnam, but commanders see no reason why U.S. technology cannot produce heavy-lift helicopters on the order of the 50,000-lb. lift capacities of the Russians.

Lighter weight water purolators are also needed.

Pathfinder teams dropped or infiltrated into forward areas to prepare landing sites for helicopters have been used successfully in Vietnam, but new equipment development is needed: lightweight omnidirectional homing beacons, refinements to IR and visual light glide slope landing lights, and lightweight GCA equipment. Ability to do this effectively also permits diversionary, fake landings to be made at night—a technique presently very effective in daylight.

Commanders also say that much needs to be done to make helicopters quieter.

SEARCH AND RESCUE

In addition to bringing fresh troops quickly over long distances into battle, the helicopter has proved itself particularly adroit in getting them out fast when wounded. This ability, carried out by skilled crews, has provided a tremendous morale boost for U.S. forces.

Make-up of the hardware for pilot rescue will change as a result of current experiences. For example, first air-to-air refueling of a helicopter took place last month, using a Sikorsky HH-3C helicopter and an HC-130 refueling tanker. Air Force rescue squadrons say they hope to put this concept into operational use here by this summer. The Navy is now using ship-to-helicopter refueling.

Combination of the HH-3C and the tanker is expected to replace the venerable HU-16 Albatross amphibian, three of which are in service here. Commanders say they would rather have a new longer-range helicopter than another new amphibian.

There are now six HH-3C's in Vietnam, with another 10 due by June and upwards of 14 to 16 more expected in following months.

Helicopter rescue experts say several other new items are needed:

—More reliable voice communications for downed pilots. The record shows that where voice communications were available, all pick-up attempts succeeded. Too often battery failures are experienced with these small radios, and rescue experts say a quick check-out system is needed which can be easily operated prior to each flight. Homing beepers are also used, but the enemy has captured some of these, using them in attempts to ambush rescue helicopters.

—Rescue helicopters have no "black night" capability, and IR homers with cockpit sensors are seen as a good potential answer. Better balloons are needed to improve the snatch recovery technique.

—Self-sealing gas tanks and armor plate have helped SAR helicopter survival, but pilots say that they should also

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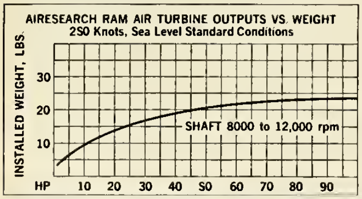

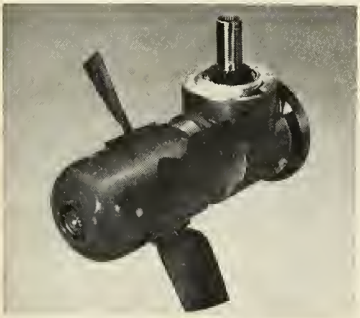

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be armed with a pair of Minigun rapid-fire machine guns.

NAVAL OPERATIONS

Naval forces in Vietnam range from a nuclear-powered carrier task force to Japanese-built junks manned by Vietnamese crews and U.S. advisors. Both ends of the spectrum are generating new requirements, but it is those associated with the huge U.S./Vietnamese "Market Time" coastal and river surveillance patrol which are bringing many new challenges to advanced technology.

There are estimated to be 50,000 sampans operating in the coastal waterways and rivers of South Vietnam. Many of these are engaged in legitimate trade. Others carry clandestine arms and soldiers from one in-country port to another. Most of the latter type escape detection despite a major effort to stop them.

Several items are needed: One is a more discriminating sensory probe for the old "bomb-in-the-suitcase" type of detection. Metal detectors, ferrite detectors, lasers, X-ray units with a 10 to 15-ft. range, designed for easy handling are required. Experts point out that there is a lot of legitimate metal aboard ships, and new designs must take this into account so that amounts beyond established norms are registered. These devices must be able to penetrate wood, cartons, fish—even manure.

There is nothing in the U.S. boat armada now in Vietnam which can move through the area between the surf line and the beach, though sampans can easily move through one or two feet of water. This has caused problems in extending inspection close to shore. The Vietnamese are using 100 specially designed, shallow-draft Japanese junks for this with some success.

High-ranking Navy officers say the U.S. will experiment with the Bell SK-5 air cushion vehicle here; however, they voice concern over the vulnerability of its propeller to gunfire when operating near defended beaches. Helicopters are also being considered, but their availability for this mission has been a problem.

Though many aircraft are used on patrols, Navy officers would like to have something like the old PBY, adding a new radar, for a low, slow, good visibility spotter plane.

Patrol craft—River operations also pose a challenge if the U.S. intends to be able to develop river assault groups for this type of warfare. "We need something that can really slug it out," say Navy admirals. Initial U.S. efforts in designing new river patrol craft (RPC's) were unsatisfactory and production was stopped. Experts see a need for something on the order of the old French STCAN—a heavily armed, small, steel-hulled canal and river escort vessel that could take hits with mines or recoilless rifle or 30-cal. machine guns without much trouble.

The Vietnamese have modified U.S. LCM's and added 20-mm, 40-mm, and 50-cal. machine guns for this, but the flat hulls make it somewhat more susceptible to mine damage, though only an explosion directly under the engine room will sink it.

Initial U.S. RPC designs attempted to greatly increase speed of patrol craft without increasing the size. The result was "aluminum hulls which can't slug it out. We also tried to get away from V-shaped hulls for shallow draft, but then they became more vulnerable to mines. We would like to have speed for patrol and firepower for escort duty, but perhaps all these missions aren't compatible." The need for systems analysis is apparent to officers here.

Part of the problem, say top-level Navy officers, is that boats are getting too sophisticated for the type of environment found in Vietnam.

The U.S. will shortly bring to Vietnam a new type of patrol craft to work on the wide rivers such as the Mekong and the Saigon. This will be the PBR-type plastic-hull, diesel-driven, shallow-draft vessel capable of very high speed. It will mount 30- and 50-cal. machine guns and 40-mm grenade launchers. It also is radar-equipped. Intent is to aid legitimate sampan movement during the daylight and exercise better control of curfew at night.

Use of new 50-ft.-class Swift boats by the Navy, armed with twin 50-cal. machine guns and 81-mm mortars, in combination with Coast Guard patrol boats, has done an effective job of stopping sea traffic coming into Vietnam at both the Cambodian and North Vietnamese borders.

New lightweight materials suitable for armor plate—if the price could be brought down—would mean considerable progress in the small boat field, allowing higher speed and better armament.

Rocket-propelled 20-, 40- and 105-mm ammunition now in development has created interest among patrol craft commanders, offering advantages over 57-mm recoilless rifles which have clearance problems fore and aft on a small craft.

For improved area fire, commanders are interested in adding 40-mm automatic grenade launchers modified to handle both 400- and 2,000-yard shells to give a wide range of high-trajectory indirect fire.

Special Forces teams operating in the delta region have used their 42-mph airboats with great success over the wet grass and paddies. They expect to buy

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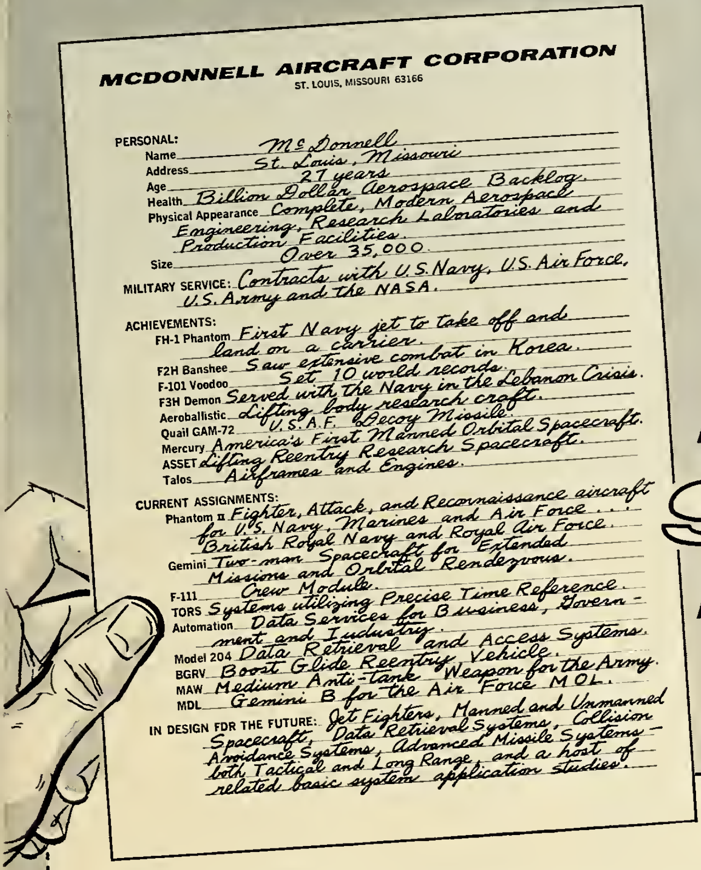

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BGRV Boost Glide Reentry Vehicle.
MAW Medium Anti-tank Weapon for the Army.
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about 30 more. "They make so much fuss," says one officer, "that the V.C. can't tell which direction we're coming from."

Carriers—Further offshore, the Navy nuclear task force provides a sharp contrast with the other Navy operating inland.

Use of pairs of H-46 helicopters for vertical replenishment operations between the USS Enterprise and its versatile task force supply ship, the USS Sacramento, have cut underway replenishment time for the carrier substantially. Transit time between the two ships for one of the helicopters, including pick-up and delivery, is about one minute. The system has reduced the carrier's vulnerability to submarine attack during this normally dangerous period.

Actually, despite the very efficient operation of the Sacramento, Navy admirals point out that if the ammunition and store supply ship were nuclear-powered, it would be better able to keep pace with the task force, carry more stores, and in effect provide a carrier task force which could steam to station and operate completely independent of support of any kind for a month.

Naval gunfire directed from offshore in support of ground operations has also been plagued, on occasion, with unexploded shells. Officers add that there is need for more effective anti-personnel rounds.

SUPPORT EQUIPMENT

There are other lessons to be learned in Vietnam—some very earthy.

Effective measures to control dust are needed to keep it from fouling machinery, reducing visibility, and running up the numbers of GI's in hospitals with serious respiratory infections. Sand and soil stabilization techniques and tillers for laying roads and runways need to be improved.

Perhaps most important is reduction of the complexity of U.S.-built engineering equipment.

As one Army officer puts it: "We have one thing to learn from the French and Vietnamese. Those cabs in downtown Saigon are probably 1937 Renaults, and there is nothing that can break on them that can't be fixed with baling wire. If you look around this country, you will see a lot of expensive U.S. engineering equipment which is idle because the part it needs is big, expensive, and can only be had in Detroit."

Throughout Vietnam, a look at the fighting forces today leaves no doubt that there is urgent and widespread need for further application of advanced technology. The proof is the success of its application to date. ■

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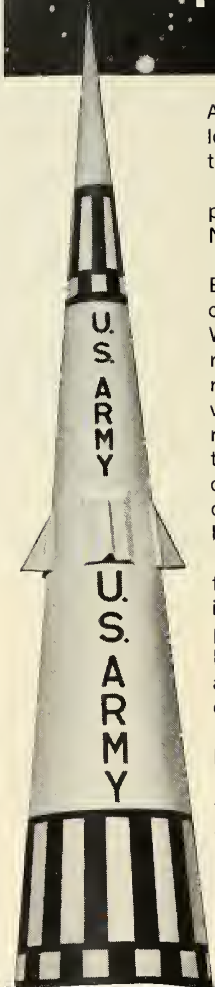

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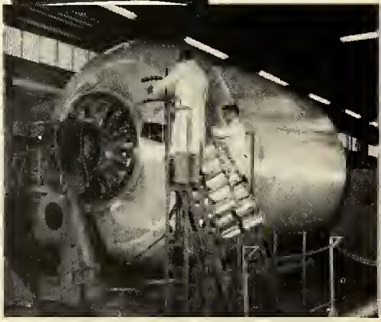

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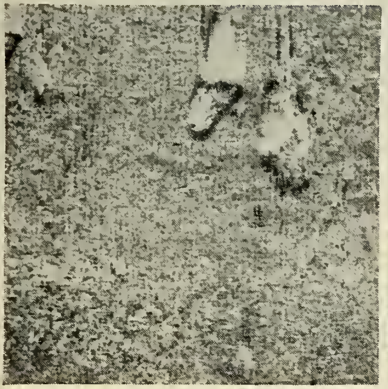
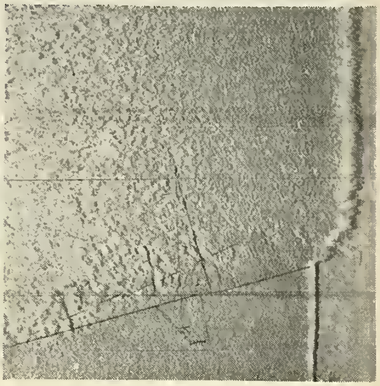


1. Downed aircraft

2. Lost drilling rig



3. Earthquake fault

4. School of fish or shrimp
5. Sunken ship
6. Geological characteristics
7. Current patterns in sand
8. Submerged instruments and floats
9. Channel and harbor topography
10. Channel and cable survey

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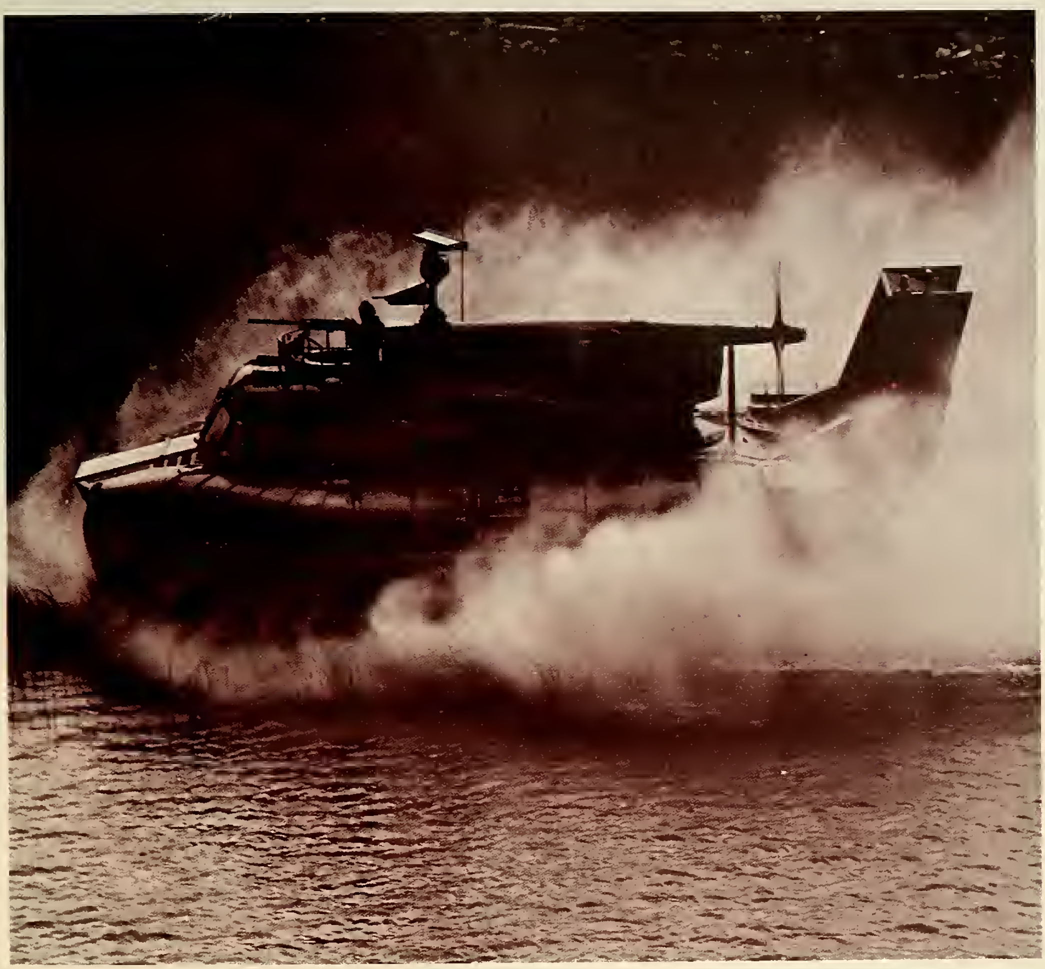


SECTION II

THE MILITARY AND INDUSTRY RESPONSE

Mobility Problems Still Vex Army

Mobility Command to spend $400 million, 80% with industry, over next several years to improve present vehicle concepts

by William S. Beller

U.S. TROOPS IN Vietnam, although in need of highly effective cross-country surface vehicles to travel over terrain as diverse and perverse as any in the world, will continue to use mostly conventional trucks, trailers and boats.

This situation is not a confession of an Army weakness as much as it is a measure of the enormous difficulty in developing non-specialized vehicles able to swim across streams, clamber up almost vertical banks six feet high, trundle through swamps and rice paddies, ride over shifting beach sands, and move at high speeds over hardened roads.

The U.S. Army Mobility Command (MCOM), Warren, Mich., will spend more than $400 million during the next several years on a research and development effort to solve some of these vehicle problems. Not unexpectedly, MCOM will use much of the money to upgrade present vehicle concepts rather than devise radically new vehicles. About 80% of the R&D money will go to industry.

Calling for "greatly increased land mobility" for U.S. forces, Maj. Gen. William W. Lapsley, MCOM'S commanding general, said earlier this month that his agency is actively pursuing this goal by studies of advanced vehicle design, high-performance turbines, variable compression ratio and other very-high-output engines, electric drive systems, hydro-mechanical and hydrostatic transmission systems, and land locomotion and soil analyses.

Outlining R&D opportunities for industry in the field of mobility support equipment, Lapsley said, "We need silent engines, lightweight precise power turbine generators, practical fuel cells, and new sources of energy and new propulsion systems for heavy equipment." He described the need for improved amphibious and river assault craft. He said there is call for better fuel handling, including storage and dispensing systems.

For rough terrain—Gama Goat (XM561) is one of the few vehicles going into production that does not have its genesis in a vehicle used in Korea or earlier conflicts. Developed with company funds at Ling-Temco-Vought, Inc., the first production units of this 1¼-ton truck are scheduled to reach Vietnam next year.

This new vehicle can "go over rougher terrain and swim inland waters better than a ¾-ton truck," an Army officer who has closely followed the vehicle's tests, told MISSILES AND ROCKETS.

Gama Goat is made up of two lightweight bodies—a four-wheel tractor and a two-wheel trailer—connected by a unique link that permits each of the bodies to pitch and roll independently. Yet the vehicle has six-wheel drive, if desired, and simultaneous front- and rear-wheel steering.

It is easily carried by aircraft and helicopter and may be parachuted to ground even with full payload. Powered by diesel, it has a cruising range of nearly 400 mi. An initial buy of about $15 million is planned for FY 1967.

"We want to keep the soldier as mobile as possible and therefore the emphasis is on cutting down the weight he has to carry," M/R was told during an Army interview. "If we can eliminate an ounce, two ounces through lighter belts, boots or any other means, we count this significant." In World War I, a fully equipped man carried a pack of 80 to 90 lbs. In Vietnam, the "existence load" for an infantryman is 30 to 35 lbs., including weapon, ammunition and two canteens.

These comments were a preamble to the Army's espousing the advantages of Gama Goat. "It can stay with the infantryman much of the time, carry his ammunition, give him more firepower, conserve his energy."

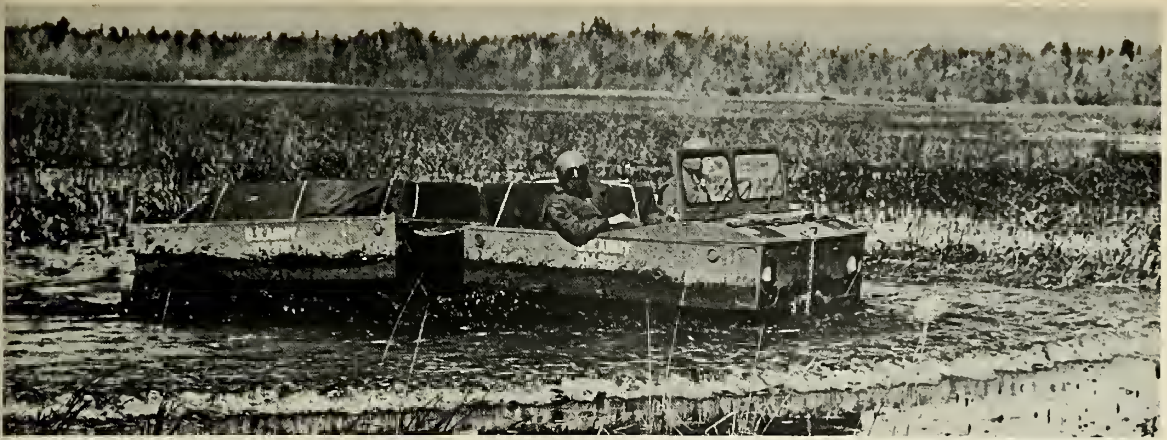
Vietnam terrain—The key to Gama Goat is its off-road performance. Yet it cannot traverse swamp, mount even moderately deep river banks, or make speed down a water-filled canal. The military dilemma in Vietnam stems from the terrain.

The Mekong is one of the great rivers of Asia. From its source in the high plateau of Tibet, it meanders through much of Southeast Asia before flowing into the sea through the Mekong Delta. The heavily silted river is only about six feet deep in the delta and is navigable only by shallow-draft boats, and then only for a hundred miles or so upriver from South Vietnam into Cambodia. A traveler along the Mekong to Central Laos would have to make frequent portages, particularly in the dry season.

In the delta area itself, the low, level plain is nowhere more than 10 ft. high, is used extensively for rice cultivation, and is criss-crossed by about 1,500 mi. of canals. About 1,000 of these shuttle traffic to main waterways. The sludge flowing through these waterways is described as "too thick to drink, too thin to plow."

Mud banks prevent deep-draft ships from using the rivers in the delta area except for the Song Sai Gon River, which is navigable to Saigon for vessels with drafts up to 19 ft. Shallow-draft craft and the hurricane boat—an airprop type similar to those used in the Florida Everglades—are employed for canal travel. In drier seasons, when mud is not a problem, the M113 armored personnel carrier can negotiate the canals because of its swimming ability. "We're using the M113 very successfully in Vietnam, we're very pleased with it," an Army spokesman said. The M113 is propelled by tracks and can carry a squad of men.

The problem is not only one of traveling along canals but also that of getting out of them onto the land. Thus, the Army is retrofitting the M113s with



ABOVE: The XM-571, made by Canadair, can climb a wall 18 in. high, travel along a road at 30 mph, and swim a stream at 2 mph. RIGHT: Looking like a tracked version of the Gama Goat (see p. 76), the XM-571 assault carrier is under Army evaluation for use by troops in Vietnam.

capstans to allow one vehicle to pull another over the banks. The banks of the canals can be four feet deep from water level to the top, and six to eight feet in the dry season and almost perpendicular. On the other hand, amphibious vehicles have difficulty negotiating a vertical wall even 28 in. high. This is close to the maximum height of a rice paddy bank.

In the dry season, the rice paddies present no problem for surface vehicles. When flooded, they are mud but navigable if a vehicle can reach a firm base or is able to swim in the substance.

Dense jungles cover the southernmost tip of the delta, known as the Ca Mau Peninsula, and mangrove swamps make up the shoreline. A rugged mountain chain forms the border between Vietnam and both Laos and Cambodia. The Chaine Annamitique, as it is known, ends at the Mekong Delta about 50 mi. north of Saigon. The central highlands rise east of the mountains in South Vietnam and contain lush growth and rain forests. The coastal plain, or central lowlands, extends along the sea from the Mekong Delta northward to the Red River Delta, whose chief city is Hanoi.

Trails and roads can be used to get through the rain forests. No surface mobility is possible except by foot, unless a path is cleared first.

The mountain areas have precipitous slopes and are difficult to climb, even by foot, without paths or roads. The coastal plain extends inland several miles. Traveling in this area is generally good if the Viet Cong do not interfere. The rivers and streams are fordable even by small vehicles and often have sand bases. There is not much heavy vegetation in the area. Loose beach sand is difficult to travel over either by foot or vehicle, but this problem is avoided by moving inland a couple of hundred yards where the sand is more firmly packed or replaced by soil.

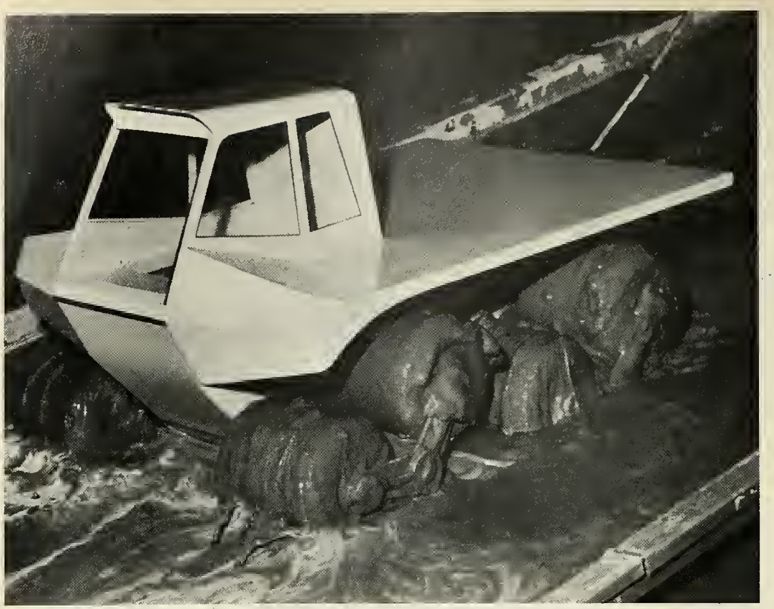
The jungle is impenetrable unless the troops cut their way through it. Nevertheless, the Army is looking for a way to mechanize the job. One suggestion calls for using two tractors with a chain between them to knock down the trees, thereby clearing a way. This system would not work in the rain forests because the trees are too big.

Swamps are almost impossible to get through except by foot and difficult even this way. In a mangrove type swamp where the trees' roots may stabilize the ground, there is an occasional canal that can be used by a shallow-draft boat.

Marginal terrain vehicles—The Army is asking for "a lot of help" in devising marginal-terrain vehicles, that is, units able to operate in swamps and rice paddies. The helicopter is the only answer the troops have now for fast mobility in marginal terrains. Travel by foot or boat means slower mobility, if indeed, traverses are possible at all.

With such vehicles so urgently needed in Vietnam, the Army is very much interested in Canadair Ltd.'s airroll. Called the Dynaroll by the company, it is designed around the continuous "rolling track" principle, similar to that used on tanks. Two sets of low-pressure tires are mounted on broad carrier belts. Large pulleys drive the belts and tires around an outrigger or platform on each side of the body, propelling and supporting the vehicle when on the bottom and rolling freely when on the top. The Marine Corps has already evaluated such a vehicle at its Landing Force Development Center, Quantico, Va., and the Army Tank-Automotive Center, Warren, Mich., will soon buy several models for the Marine Corps to run full-fledged tests, according to Brig. Gen. E. E. Anderson, deputy chief of staff (research, development and studies), U.S. Marine Corps.

Quick fixes—The Army intends to send some marginal-terrain vehicle to Vietnam soon, but the service is not yet certain which one it will be. "We're still working with the Vietnamese to see which one they want," said an Army official. The Huskie (M116) all-climate amphibious cargo and personnel carrier



One-fifth scale-model of Lockheed's TerraStar "walks" through deep mud on its major wheel assemblies. The vehicle is a 1¼-ton logistics carrier.

is the leading candidate. Able to carry a 1½-ton payload, this is a tracked vehicle already operational in Alaska. "It's not something we have to develop or alter for Vietnam," he said. It is a standard item, can fit into a Chinook, and "could be put into production with little effort."

Canadair's Dynatrac (XM-571) is another vehicle the Army is considering as a "quick fix" for a high-mobility assault carrier able to travel over marginal terrain. Resembling a Gama Goat with tracks, the XM-571 is lightly armored, weighs about 9,000 lbs., can be air-carried with a 2,000-lb. payload or 10 fully equipped soldiers in a Chinook, and is armed mainly with automatic weapons.

The vehicle can climb a vertical wall 18 in. high, operate at 30 mph and swim at 2 mph. The Army is considering the vehicle as support equipment for helicopter-delivered troops and reconnaissance. The XM-571 can go into almost immediate production if a requirement were given for the vehicle.

Long-range goals—For short-range work, the Army will not go far afield but will stay with existing vehicles or those in advanced development, modifying where necessary. The need is now. But in the longer view, which the Army defines as something more than a year away, the service is looking at several exotic vehicle concepts. One is the airroll principle mentioned earlier. Another is Lockheed Aircraft Service Co.'s TerraStar, a 1¼-ton logistics carrier using a unique locomotion idea.

Four major-wheel assemblies support the cargo body of TerraStar. Each assembly is comprised of a set of three minor wheels mounted on stub axles and located radially about the major-wheel axle by means of a spider. The minor wheels carry wide-base, low-profile, low-pressure tires. The vehicle drive system is arranged so the driver can engage either minor-wheel drive or major-wheel drive.

For normal operation over roads and some soft plastic surfaces, only the minor wheels drive and the vehicle performs much like a conventionally wheeled vehicle. However, under surface conditions where the ground is unstable and highly plastic, and considerable sinkage and slippage of the minor wheels develops rapidly, then the minor-wheel drive is disengaged and the major-wheel assemblies do the driving, providing something like a walking motion for the vehicle.

A ground-effects machine will soon go to Vietnam for test. Army officials are not too enthusiastic about its use anywhere but over flat terrain. Forests, canyons and even large rocks or holes in the ground are hazards for the machine. If it attempted to fly over the surface of canals, the banks would limit the machine's size and reduce the payload to unacceptable values, M/R was told.

Much as the Army needs highly mobile surface vehicles for Vietnam, the service is steering clear of gadgetry.

Current program—The first large quantity of a large cargo carrier designed as a swimmer will enter the inventory in two years. This is the Ford Motor Co's 5-ton, 8x8 cargo truck, XM656, scheduled for production early in 1968. Its 210-horsepower engine can "live off the land," because it can run on almost any liquid hydrocarbon fuel and no readjustment is needed.

The eight-ton GOER series of Army cargo carriers will also enter the inventory in 1968. They are all swimmers, show good off-highway performance, and have low-pressure tires, all-wheel drive and articulated bodies. They may later on become multifueled. All the GOERS have high mobility and will be issued to troops in forward areas to improve tactical mobility, particularly cross-country performance.

The FY 1966 program for Army trucks, trailers and other non-combat vehicles now totals $608 million, of which $253 million is included in the supplemental request, Defense Secretary Robert S. McNamara told the Senate subcommittee on DOD appropriations last month. For the next fiscal year, DOD asked for $526 million for similar tactical and support vehicles. ■

Ling-Temco-Vought's Gama Goat, articulated for rough terrain such as that encountered in Vietnam, is also a 1¼-ton vehicle scheduled for introduction this year.

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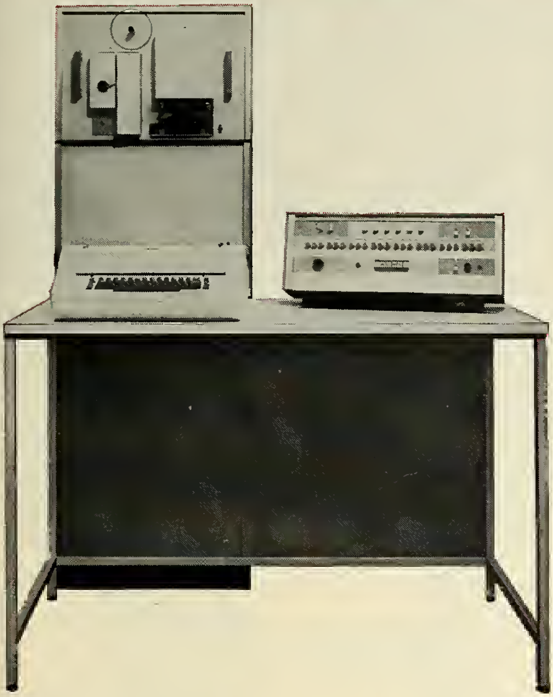

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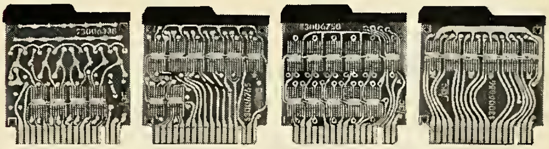

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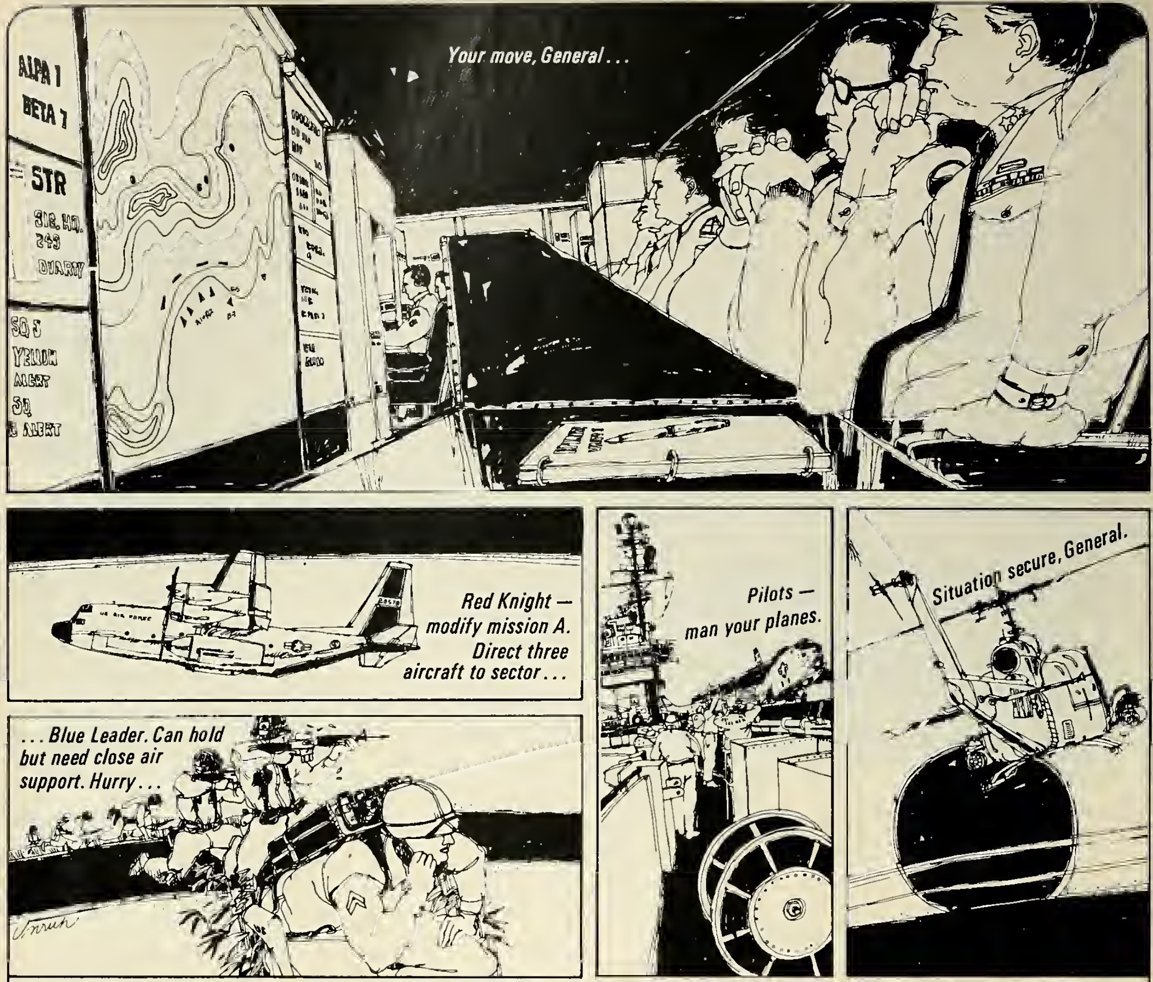
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A self-contained unit that is operational either in the air or on the ground, ABC^3 is an electronic war room that permits battle commanders of joint services and their staffs to conduct complete combat operations in a "know-exactly-for-yourself" situation. Through HF, VHF and UHF, battle commanders in ABC^3 maintain complete communications with and control all strike forces — air, sea and ground — for total and maximum effectiveness.

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French-built STCAN is rugged, heavily armed craft doing river assault duty in Vietnam.

New Designs Seen for Patrol Boats

Navy looks to air cushion vehicles, hydrofoils for small-craft needs; high-performance engines, lightweight armor still sought

PENTAGON OFFICIALS believe that air cushion vehicles (ACV) and hydrofoils will solve their small patrol boat problem over the next 10 to 15 years.

Three ACV's are currently being deployed to South Vietnam to test their operational feasibility.

Together with new gas turbines, they are the Navy's latest effort to develop the ideal patrol boat—"a 35-ft. battleship with a 2-ft. draft."

The effort involves some tough technical problems—the need to develop better diesel engines, lightweight armament, lightweight armor, shallow-draft hulls, and silent-running boats.

For air cushion vehicles, in particular, there is also a pressing need to improve design of the vehicle's fan-type propulsion system to decrease its vulnerability to ground fire.

Most of the coastal and river patrol boats now in use in Vietnam are not based on any new technology, although the Defense Dept. has procured about 250 of them in the last three years.

Reportedly, their cost was approximately $50 million. Most of the boats are being procured in the current fiscal year, during which $30.3 million is being spent on them. In FY '67, DOD expects to spend only $5.6 million.

Other new limited-war boat-building items in the budget for the next fiscal year include $13.5 million for reactivating and converting landing craft and other boats and $6.6 million for harbor craft to be used in South Vietnam.

While procurement for Vietnam is tapering off, it is clear from talks with DOD officials that a firm which comes up with a new patrol boat using advanced technology to get a high-performance power plant plus new lightweight armament and armor would find a ready market.

Air cushion vehicle—One of the most advanced concepts now being tested as the long-range answer to patrol boat problems is the air cushion vehicle. This concept offers promise because the ACV can move over the water, vegetation and dirt at fairly high speeds.

Three of these SK-5 vehicles were developed for the Navy by Textron Inc.'s Bell Aerosystems Co. under a $1.5-million contract. The ACV is the American version of the British SRN5 Hovercraft. The hulls for all three craft were built by Westland Aircraft Ltd. in England and shipped to Bell for modifications and final assembly. Navy sources in Vietnam expect the SK-5's to be operating in Vietnamese waters this spring.

The SK-5, according to Bell, can be used for amphibious assault missions, as an emergency vehicle for fire fighting, search and rescue missions, for high-speed passenger transportation, harbor and river patrol and as a logistics support craft.

A single General Electric Co. LM-100 1,000-shaft-horsepower marine gas turbine engine drives both the lift fan, which forces air downward to create the air cushion beneath the craft, and the

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Resembling a Civil War era gunboat, modified U.S. LCM is another river patrol craft that can take a beating from a variety of small arms and mines.

aft-mounted propeller, which provides propulsion at speeds up to 60 knots per hour.

The seven-ton SK-5 appears to ride only a few inches above the surface, but the hard bottom of the craft actually travels on an air cushion more than four feet thick.

Vehicle performance—Control of the ACV is achieved by bleeding air from the cushion through a trunk lifting device and by rudders mounted on the twin-fin, tailplane unit, which operates in the slipstream of the craft's propeller.

Its performance includes a maximum speed of 60 knots, 210-mi. range, endurance of 3.5 hours; and wave clearance at 40 knots of 4.5 ft.

It can clear such obstacles as a 3.5-ft. solid wall, 5-ft. earth mound, and 5 to 6 ft. of vegetation. Ditches up to 12 ft. wide and 8 ft. deep can be crossed at a speed of 20 knots. Its passenger-carrying capacity is 15 to 18, plus the operator.

Thus far, three basic types of ACV's have been developed:

—Plenum Chamber—basically an inverted chamber with a hole cut in the top. Air pumped through this hole into the chamber creates the pressures sufficient to lift the craft. Daylight clearance is approximately equal to the thickness of the air jet which flows out of the bottom perimeter of the craft.

—Annular Jet—the most widely used means of developing an air cushion. It attains a daylight clearance two to three times higher than the thickness of the escaping air.

This is accomplished by fans forcing the air downward through slots around the periphery and slanting the air flow inward toward the center of the ACV.

The angled air flow provides a seal which keeps about 60% of the air from leaking out.

—Flexible Trunks—The addition of trunks or skirts increases the obstacle or over-wave clearance by an amount almost equal to that of the skirt length.

Bell has also built the Hydroskimmer, the largest and most powerful ACV built in the U.S., for the Navy Bureau of Ships. It weighs 45,000 lbs. and has a top speed of 70 knots or 80 mph.

Designated the SKMR-1, it is being used in a test program at Lake Erie in order to obtain data for the design of even larger ACV boats.

Larger craft might be used for other missions, including anti-submarine warfare, landing and patrol operations, mine countermeasures, and cargo and rescue operations.

Hydrofoil applications—The Navy is also studying the hydrofoil for possible use as a patrol gunboat.

Last month the Navy contracted with the Boeing Co. and Grumman Aircraft Engineering Corp. for two 50-ton Hydrofoil gunboats for coastal patrol. Development time is expected to be about two years.

The hydrofoil, which rides above the water but which has foils which extend down into the water, is favored because of its relative higher speed than conventional boats. The hull is lifted out of the water as the boat achieves greater speed because of the dynamic interaction of the air foils and the water.

However, while they are almost silent when approaching the target, they can be heard when they leave. Also, they have a draft in some cases of 8 to 10 ft. and thus could not be used for river patrolling. They are, in general, more vulnerable to mines than ACV's, but less vulnerable than more conventional hull boats.

The Navy is currently doing research and development which could lead to the building of a 300-ton hydrofoil boat. It also plans to do some research into developing better foils. Currently, there are two basic types—the surface piercing foil which requires more control and the submerged foil which rides a little deeper in the water.

The Navy has also funded construction of a 250-ton hydrofoil by Lockheed and that firm is currently doing some in-house research on it. Boeing has also built a 108-ton hydrofoil.

Technical problems—One thing which perplexes the Navy about the U.S. boating industry is that European firms build better diesel engines than the U.S.

While the Navy would like to buy the European models, according to Pentagon officials, it usually does not do so because of the U.S. balance of payments problem.

The current Navy trend is to move to the use of the gas turbine to power patrol boats. One major problem here is the heavy expense. For example, a 700-hp gas turbine costs $20,000. A firm able to cut this cost substantially would probably find a huge market.

A problem with a diesel engine is that it can always be heard. The gas turbine on its way in from the sea usually cannot be heard. This accents the real need for new muffler systems which would make patrol boats either completely silent or much more quiet than current units.

There is also a real need for the development of new lightweight armor which can stop a 30-cal. bullet fired from 100 meters.

A new ceramic armor material is undergoing trial tests. It is somewhat lighter than conventional armor, weighing only 9½ lbs. per sq. ft. compared to 12 lbs. for metal armor. However, costs are a little higher, $120 per sq. ft. compared to $100 for conventional materials.

Another needed improvement for future patrol boats is new lightweight armament which can increase firepower. Range is usually not the most important consideration in river and coastal patrolling, but, as one Navy official said, "the big bang is."

Boats currently in Vietnam are using such World War II armaments as 81- and 60-mm mortars, and 30- and 50-cal. machine guns. ■

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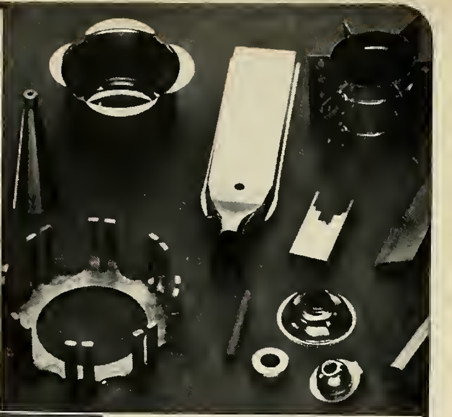

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Helicopter Warfare Opens New Era

Huey Cobra, AAFSS will be first of specialized craft stressing integral weapons; corrective systems needed for firing accuracy

by Arthur C. Bass

SUCCESS OF U.S. commanders in their massive use of helicopter-borne troops and weapons under fire has spawned the single most revolutionary new combat doctrine yet to emerge from the Southeast Asian battlefield.

The impact of this rapidly built-up force is enormous. It is, of course, causing major re-examination of military tactics and organization of air cavalry units. Beyond this, it is forcing a reappraisal of the basic design philosophies which have guided helicopter development in the past, of the helicopter industry itself, upon which the United States is now suddenly dependent for a front-line weapon system, and of the existing environment for supporting the research and development work to guarantee future growth and military effectiveness.

Bringing troops to the battle area prepared to fight, without the fatigue of the march wearing away their effectiveness, has become the primary mission of the helicopter. The Army calls it air mobility. The Marines call it vertical envelopment. The methods for troop movements are becoming more similar and the means of supporting this movement more sophisticated.

The helicopter war is proving many things. Included is a point that only a few military planners and fewer manufacturers will openly admit—the new military need means that the success of the helicopter can no longer rest on its traditional role as a utility, all-purpose craft.

Weapons factor—Air mobility for supporting weapons has become the most significant new factor.

The armed convoy certainly is not new, but attempting to protect troop movement by air under a complete weapons umbrella—from take-off to deployment—certainly is.

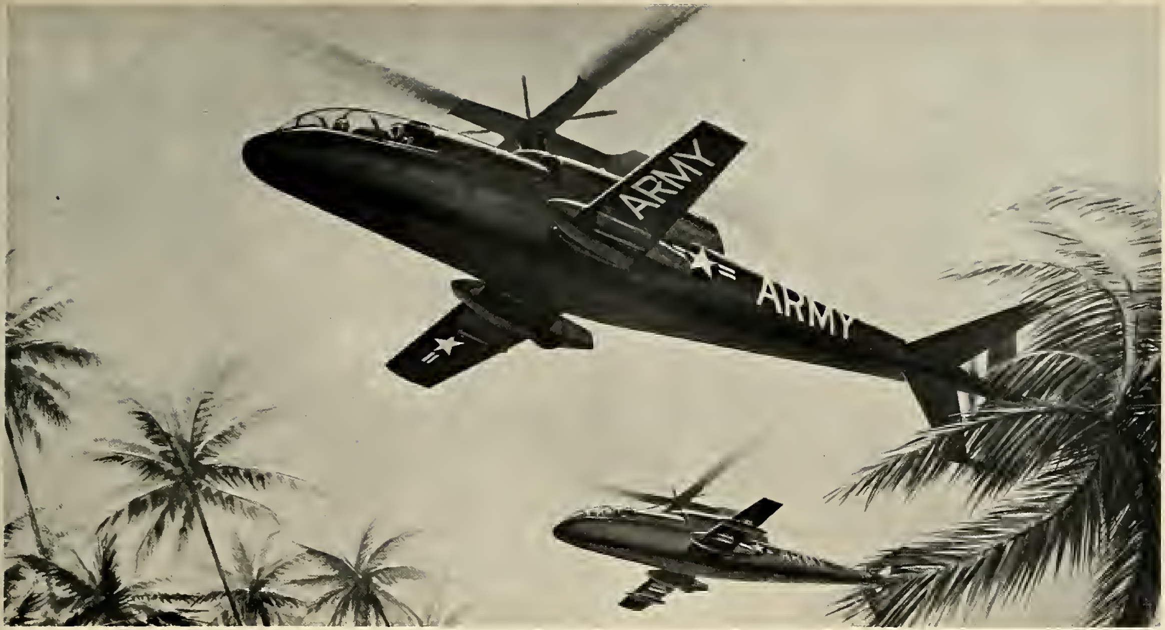
The prime piece of equipment being used in an effort to accomplish this is the Bell UH-IB "Iroquois." Designed originally as a utility transport, the IB became armed more through necessity than by design. As a stop-gap piece of equipment it has more than held its own. The gap, however, is beginning to widen.

The optimum 90-95-mph-performance IB's can no longer keep pace with the higher air speeds of the 110-mph HU-1D troop-carrying version and the 140-plus mph of the Sikorsky and Boeing Vertol transports. They not only slow the convoy, but if they have to contend with targets enroute it is seldom that they can dash back to the main body to support the landing phase of the operation.

This, in part, explains the Army's first procurement of a single-purpose vertical-lift machine—Lockheed's Advanced Aerial Fire Support System (AAFSS). The craft (due in service sometime in 1968-69) is designed to provide an airborne weapons system for heliborne movements with the necessary speed to accompany the formation, probe ahead, answer fire from beneath with a weapon system that deflects downward some 70 degrees while maintaining level flight, and to provide a higher degree of supression of ground fire along the flight path.

Even if diverted, AAFSS is designed to have the speed to rejoin the main

Bell's Huey Cobra in flight. DOD has just approved quantity production of this swift weapons platform. The Cobra will serve as an interim armed helicopter until introduction of the AAFSS. Cobra will have top speed of 180 mph.



Artist's concept of Lockheed's Advanced Aerial Fire Support System, slated for acceptance in about 1969. Craft should provide true second-generation capability for the helicopter as a weapons platform. Two-man crew will have varied weapons mix.

body and provide supressive fire between the lifting of close-air-support and consolidation upon the objective by the ground unit.

There is, however, a period of at least two years of hard war ahead in which the HU-1B will decrease in effectiveness as the helicopters it supports are upgraded in speed necessary to counter the greater firepower and more effective anti-helicopter tactics anticipated from the enemy.

Bell has accomplished some upgrading of the 1B with a "540" kit to increase its speed, and this is already in Army use. It provides a cruise airspeed 13 knots higher, using a new rotor system, and lengthens endurance by better than one hour with a larger fuel capacity. What it does, in effect, however, is point up the problems of design compromise in the helicopter. These increases in speed and range are offset to a great extent by a lowering by 600 ft. of its hover performance out of ground-effect.

On to Cobra—Faced with the hard facts of compromise in carrying out armed helicopter operations prior to the arrival in the battle zone of AAFSS, the Army early this month successfully made its case for deployment of the Bell "Huey Cobra" as an interim weapons ship.

The craft will begin to enter the inventory in mid-1967.

What Bell offers for the Cobra are performance parameters that yield a top speed of about 180 mph loaded (cruise would be about 150 mph—enough to keep up with the present convoy speeds). Over a 50-mi. distance, the Cobra is designed to deliver twice the weight of ammunition and operate in the target area three times as long as the armed UH-1B escorts.

A detailed proposal has been made to the Army covering performance, delivery dates, production schedules and pricing. Bell has emphasized that its Model 209 is nothing more than an interim, quickly available weapon system.

Cost is to be kept down by utilizing the Model 540 "door hinge" rotor system and power package components. The semi-rigid rotor system offers an increased degree of effective blade-chord stiffness by damping out oscillatory loads, particularly in its higher speed range. Commonality with the 1B is said to reach 80%.

Weaponry is very much in line with the AAFSS concept. GE's XM 134's are mounted in an Emerson Electric TAT-102 turret under the nose, having an azimuth coverage of 230 degrees—elevation up to 25 degrees and deflection downward to 65 degrees. Additional weapons—at a compromise somewhere along the line—are possible, and can be slung under the stub wings. The turret can be adapted to mount a 40-mm belt-fed grenade launcher.

Crewmen will be protected much better than they are on any helicopter now in service. New Philco-Aeronutronic airform armor plating, constructed from two thin, light steel-alloy sheets mechanically welded together, is a leading improvement in this area. The outer sheet is designed to break bullets into fragments and the inner prevents the dispersed fragments from penetrating. The seats in the two-place craft are made of Ausform, and are also fitted with Ausform side panels that can be raised to shoulder the girt on both sides of each crew member and locked into place. The panels weigh about half as much as armor plate, cost less and are claimed to be easier to contour than the plate.

The narrow—3-ft.—width of the fuselage is what the UH-1 would have had, according to Bell engineers, if its initial mission requirement had been fire support, rather than medical evacuation.

Hopes for AAFSS—The aim of the AAFSS program is to achieve the maximum in suppressive area-type fire. Greater accuracy is anticipated from the rigid rotor concept that Lockheed employs. Its high degree of control power maneuverability and its stability is proving out as a stable weapons platform in slow and hovering flight. Accuracy (in forward flight) is further enhanced by its stub wings and use of the forward thrust of its wing-mounted GE 3,400 hp T-64-S4A gas turbine engine. This unloads the rotor as forward speed increases, making the accuracy of the projectile more a product of fuselage attitude than in any previous helicopter type.

The two-man crew will have a variety of weapons available for both point and area fire—including all advances that prove out in the more sophisticated weapon programs to be completed over the next several years. The GE XM-134, a rotating six-barrel affair capable of firing 7.62-mm rounds at a rate of 4,000 per minute, 40-mm M-5 belt-fed grenade launchers, and aerial rockets, represent the current armament package.

Together, the Cobra and AAFSS signify a break from utility design and a recognition that special-purpose applications are growing. It also suggests a narrowing of type, in that fewer manufacturers will be providing the military with its aircraft requirements, with each service maintaining a select inventory. This cuts down parts acquisition, training time and, ultimately, the number of manufacturers that can afford to experiment with ideas and turn them into reality.

Rigid rotor ramifications—Whether any other manufacturers plan to move into the rigid rotor concept is yet to be determined. Some have already made overtures in this direction, as reflected in Bell's "door hinge" 540 system. Many others are holding off, waiting to see whether the flexing of the rotor blades and the loads imposed on the other dynamic components maintain the low stress levels proclaimed by Lockheed.

Further favoring the rigid rotor concept is the fact that it has fewer components and a much less complicated control system. Even if some of its weight saving is lost in the course of making the aircraft structurally sound, its overall impact on the helicopter industry will be formidable.

Armament—Aside from the problem of an interim AAFSS there is that of weapons development to keep abreast of the more sophisticated aircraft and tactics.

Stuck as the helicopter has been for many years with hand-me-down fixed-wing instrumentation, it finally is evolving systems of its own that answer its unique operating requirements.

The weight of weapons systems is generally the major drawback to their adaptation to the helicopter. With AAFSS the weapons are being designed for the aircraft.

Sighting to a target and holding it despite the unstable vibrating helicopter is still a problem. Bell is doing considerable research in this area, offering its XM-58 airborne sighting system to improve the first-round hit percentage for the *SS-11* wire-guided missile.

For providing area fire instead of point fire, the problems of target acquisition and reconnaissance are most significant in the total effectiveness of the helicopter as a system.

Engine vibration, rotor beat, and the significant fact that any bullet or projectile leaving the helicopter has an initial trajectory in line with the thrust vector of the rotor system—which is, for the most part, independent of fuselage attitude—all combine to create the requirement for corrective systems to achieve greater accuracy. Emerson Electric and Bell Aerospace have come up with sophisticated corrected optics to eliminate vibration and provide automatic corrective inputs to the weapons themselves. The Army is looking at the Tyler Camera System's vibrationless mount recently purchased for filming from helicopters.

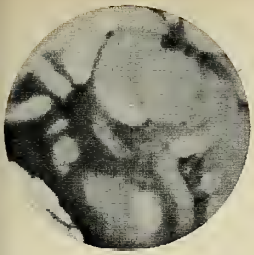
Waste of ammunition is not significant in itself, but with load already limited, the burden of ammo on the armed helicopter's mission endurance is severe. This increases the number of aircraft required to accomplish a given mission and multiplies the exposure time of the landing troops and the support aircraft to enemy fire.

Missile improvements—Because of the magnitude of the point target acquisition and hit problem, new emphasis has been placed on guided missile development (M/R, Oct. 25, p. 21).

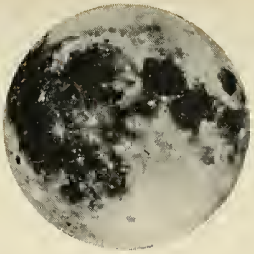
Present and near-future development of third-generation weapons includes improving upon the French-developed *SS-11* anti-tank missile currently aboard HU-1B as a hard-point weapon. Successfully guiding the *SS-11* to the target requires the helicopter to stay on the scene for an inordinate amount of time and keep within a flight envelope too restrictive for evasive action, adding critical seconds of exposure time to the aircraft and crew.

"Shoot and scoot" is the goal, and the development of new opto-electric missile guidance systems to achieve it is still felt to be some four or five years in the future. The XM-26 *TOW* subsystem being developed at Hughes Aircraft, however, will be the first real step toward this capability. With a stabilized sight that automatically feeds course-correction data to the wire-guided missile while in flight, the gun-

Cobra, center, with its 3-ft.-wide fuselage, contrasts sharply with the Army's OH-13S, left, and HU-1B. The latter is the workhorse in Vietnam today, but its slowness (90-95 mph) hampers faster craft it accompanies for fire support.



U.S. AIR FORCE



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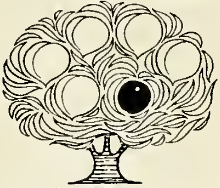

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ner has roughly 160 degrees of gimbal freedom, allowing considerable evasive action, while the target is held in the sights. The computer guides the missile to the target.

Guidance studies are widespread, with TV, infrared and radar being given the most serious consideration.

Air artillery—Area fire, the most critical form of suppressive cover, leaves much to be desired as well. The biggest aid to the gunner has been the tracer bullet.

The XM-30, designed to replace the XM-3 rocket subsystem aboard the UH-1B, makes a good package for the aircraft in that its pod-like shape will reduce the parasite drag of earlier weapons systems. One XM-140 30-mm automatic gun will be mounted at either side of the aircraft. However, area fire under less than ideal conditions is anticipated to achieve minimal hit probability on the first run and is another area wide open to research.

In proposals for R&D of air artillery, cost-effectiveness studies for employment of support weapons such as airborne 105 and 155mm's are being carried out on a small scale. Having airborne "howitzers" organic to a unit could provide mobile striking power of impressive dimensions and offer the capability of both direct and indirect fire that could turn the tide of battle. Recent studies conclude that combat effectiveness diminishes rapidly as total casualties near 30%. Two howitzers under certain conditions can be worth as many as 1,600 riflemen.

To achieve this from an aerial artillery piece or rocket that is an integral part of a heliborne troop movement has interesting dimensions. While at present the ability of the helicopter to move artillery pieces into ground positions speeds operations and enhances their probability of success, setting artillery down in no-man's land during guerrilla warfare runs a sizeable risk—and often requires a supporting force to defend the position selected.

Weapon study—Making aerial artillery lighter in weight, and creating an airframe capable of accepting the extremely heavy loads of both the weapon and the ammunition to support it, represents a trade-off between cost-effectiveness and operational effectiveness that will be considered in a study due to be completed in September.

The study includes all airborne weapons systems. It is being conducted by a joint technical coordinating group of all the services and will cover the full range of air-launched non-nuclear ordnance with an eye to lighter, more suitable weapons with less aerodynamic drag and with more advanced fire control systems. Its goal is to push suppressive-fire state of the art into a third generation that can shoot and scoot and provide the most effective possible support.

To date about 150 helicopters have been lost by all services. Army figures point up that a helicopter will be hit once in every 450 combat sorties, downed once in every 8,000 combat sorties, and lost to ground fire only once in every 13,000 combat sorties. Figures released Jan. 18 reflect only 62 Army helicopters lost to ground fire.

Impressive as these figures are, the Viet Cong are moving toward larger weapons. The application of these coupled with tactical experience against the helicopter may create more critical armor requirements in the near future.

Programs on vulnerability and methods to protect the helicopter have run through dual hardness steel, fabric-covered plastic, and aluminum oxide.

The basic aim has been to protect the crew. Armored seats of aluminum oxide are in all Hueys and Chinooks. Boron carbide, with the ability to stop a 30-caliber shell at 100 yards, is used to protect the crews, but the material is expensive and available only in limited supply from four companies.

Middle-sized—The medium-sized helicopter, for the most part, is a static area, with development anticipated mostly in product improvement for the next several years. Termed tactical transports by the Army, they are represented as a team combination of the fixed-wing DeHavilland-built Caribou and the Boeing-Vertol Chinook CH-47. The Marine Corps "team" is a combination of the Sikorsky CH-53A and the Boeing-Vertol Sea Knight CH-36A.

Boeing has increased Chinook production to 15 per month and has improved the performance on the aircraft in the process. Although considered rotor-limited in both speed and weight-carrying potential, Chinook has a new "droop-snoot" blade that delays retreating blade stall and has provided better than the 140 knots built into the ship. Originally designed to gross at 24,000 lbs., the Chinook is now at 33,000 lbs. and still growing—an upgrading of engine power and a beefing up of the transmission are under way at this writing.

The additional load-carrying pays dividends in providing 350 lbs. of ceramic armor at no real penalty in payload. To date, significant hits have been recorded on 13 of the Chinooks, with two aircraft losses attributed directly to ground fire. The armor provides protection against the 7.62-mm (30-cal.) variety of weapon and represents a step toward extending the mission capabilities of the helicopter. This is a luxury that the smaller helicopters simply can't afford with present demand for payload.

V/STOL—Since much of the logistics requirement is handled from the major depots in Vietnam, greater research emphasis can be expected on V/STOL aircraft proposals.

Vertical take-off almost invariably requires, depending somewhat on pilot technique, more power than V/landing for the same gross weight. This limits the helicopter's payload at take-off and affects the number of men or amount of supplies set down at the landing site. To operate as a helicopter from the beginning of this type of an operation to its end is not proving totally advantageous.

The idea of taking off short, with various wing configurations—using a ground roll to develop flying speed, eliminating or unloading the rotor in flight (either by letting it windmill, by "stowing" it, or by having it become part of the forward propulsion system—is a concept gaining considerable support. It would not only increase take-off gross weight significantly but its speed advantage over the standard helicopter would be a minimum of 100 mph, while retaining the ability to set down vertically through use of the rotor or other vertical applications of power.

While not totally applicable in Vietnam due to the relatively short distances involved, the concept over longer distances could, in effect, reduce the number of aircraft required for a mission, reduce the exposure time by flying higher and faster (more maneuverable and less vulnerable when air superiority is contested) and help make the front lines much more accessible.

The near future, however, dictates a continuation of the Chinook/Caribou combine, with the Chinook bearing most of the frontline burden. The cost of even a foot of prepared surface in Vietnam—away from the enclaves—often is too high to pay to achieve full Caribou utilization. However, the Army feels that Caribou's contribution is high enough to warrant continuing the team concept. Two of the larger, turbine-powered Buffalo CU-7 aircraft are being tested in Vietnam now, but there will be no further buy despite Army protests.

Engine troubles—In spite of the strides made in engine development, the raw power required for vertical lift in the high temperatures and density altitudes of Vietnam is not proving adequate—nor is the "standard day" power rating criteria valid there. Density altitudes of 4,000-6,000 ft. are common.

Performance curves in the areas of lift capability drop off to a point where over-extending the equipment is the only way to complete the mission. The concept of carrying a full squad in the UH-1D has been dropped to as low as five or six, simply to accomplish lift off. Power, as advertised, isn't always available to the pilot, since the engines might have more horsepower than the rotor shaft can absorb.

The growth potential built into today's turbine engines represents significant engineering achievement. Engine ratings, however, as they are established for the categories of take-off and maximum continuous power, are not helping the life of the engines since in many cases the power/time curves and "average day" conditions are unrealistic. In Vietnam, where engines are run at maximum power almost throughout a mission, the effect on maintenance is substantial.

Fatigue life on blades is also a problem. Sand and dust friction are eating up the leading edges well before their 1,200-hour life has been peaked.

Aircraft availability, always a factor with helicopters, has been improved considerably by a conscious effort to provide a reasonable spares inventory. New reporting procedures and standards of evaluating readiness, as well as establishing parts and personnel priorities by command and area, have resulted in increased availability. However, being available and being in the soundest condition for flight don't always mean the same thing.

Availability of the Chinook in Vietnam is reportedly at 53.9% with the Hueys about 70%. A major problem creeping into the procurement of all mechanized equipment affecting availability is that the quality-control requirements for vendor-supplied items, especially in the area of seals and bearings, are not consistent and are in need of improvement. To get at a single transmission bearing can require the removal, in some cases, of the entire rotor and transmission system. While "zero defects" is imposed on manufacturers providing the finished product, that same product in the field has a parts inventory filled with these vendor-supplied items.

Parts problems—As the manufacturers become more extended in production—Bell up to 150 Hueys per month—reliance on these items is becoming more critical for field support. Areas such as second sources of transmissions and turbine blades, as well as seals and bearings, unless put through some standard—such as the Rockwell hardness test for the forgings, can be a continuing drain on cost-effectiveness through increased down time.

With the helicopter industry operating at previously unheard-of production levels, one critical segment of the industry is being hard pressed to keep up with the demand. Spiral bevel gears for helicopter transmissions are in relatively short supply and the industry that provides them is right up against the wall. There is no stock reservoir and the gears are being used as fast as they come off the line.

A committee in the office of the Secretary of Defense is looking into the situation, but the question of the boom lasting long enough to permit either a new company or one already involved to justify further tooling up for this type of production is one that DOD appears to be reluctant to answer.

Another important goal is to achieve an all-turbine aviation equipment level for field operations in the near future. The Army, by phasing in of the new light observation helicopter, expects to accomplish this within the next few years. For the Marine Corps, it will be a longer proposition.

The major import of such a move will relieve a supply burden that has involved the shipping, storing, and using of a variety of fuels to meet the octane requirements of small and large piston-driven engines and jet engines. Every vehicle, ultimately, air or ground, will be able to accept CITE fuel.

Heavyweights—A major growth area for Army requirements that may well extend to the Marine Corps is in the heavy lift field. The Army is after as much lift as it can get. The 10-ton load carried by the Sikorsky crane was bought mainly because it was available and didn't necessitate the spending of development funds. In the interim, the CH-54A may be building a permanent place for itself. The estimated total value of damaged aircraft recovered by the crane and returned for repair exceeds the price paid for the cranes.

A good deal of the CH-54A's functional design and many of the systems that it incorporates—from being able to "kneel" hydraulically over a load and jack it up to lift the load clear of the ground, to its unique aft-facing crane operator's seat and controls, and other innovations—are very definite means to a not-so-remote big lift configuration.

A minimum of 20 tons is felt to be desirable for the Army's concept, although a 50-ton capability would handle anything in the Army stable.

In terms of technical feasibility, such a piece of equipment could be available in five years with full funding.

The Marine Corps feels that its present needs will be met by the Sikorsky CH-53A, which has achieved 201 mph and 42,000 lbs. gross weight (useful load of about 20,000 lbs.). There are no military experts, however, who would not like to have the ability to bridge rivers at a "single bound."

Most qualified military observers feel that the ultimate big-lift helicopter will be of the hot or cold cycle or "tip turbine" variety in which the power to move the rotors will emit from the blade tips themselves in the form of exhaust gases. This will reduce much of the weight of the mammoth transmission gearing ordinarily required and

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would induce lower stress levels on the gears and blades.

Here again, the concept is not new. Refinements and material advances require another look, as does the potential for financing.

If the military cannot justify such a development because of other priorities, or sees that the number to be purchased will not bear out the development costs (Army estimates run to $100 million in development costs for a four-to-a-division requirement), another method of procurement must be found. This could take shape along the lines of the supersonic transport program.

A big-lift crane can justify itself during almost any natural disaster and a host of other constructive applications.

Navigation needs—The anticipated requirement for sophisticated navigation systems has not really materialized in Vietnam, although increased enemy activity in bad flying weather is an obvious tactic. The relative compactness of operating areas and frequency of missions have resulted in greater-than-usual area familiarization.

However, a look toward expanded forms of conventional warfare indicates more sophisticated air navigation gear is required.

The Navy and Marine Corps missions dictate a new self-contained navigation and terrain avoidance system.

Called IHAS (Integrated Helicopter Avionics System), it is designed to be used on the Marines' Sikorsky CH-53A transport and Boeing-Vertol's CH-46A. These aircraft will generally originate their flights from aircraft carriers (Navy assault transports) for participation in major Marine Corps amphibious assaults. The function of the system is to permit precision navigation under the worst possible conditions with a negligible navigation error over the course of a two-hour mission.

Being developed by Teledyne, it represents the first time the Navy has given total responsibility to one company for an entire aircraft avionics system. It is also the first avionics system to extend the use of microcircuit technology toward its fullest potential.

Sikorsky's CH-53A heavy-assault helicopter is the test bed for the system, but the capabilities of IHAS make it applicable to the Army's AAFSS. This explains Army funding up to 40% of the program's $26.6 million.

Basically, the system is a display type that operates in two modes, navigation and radar. In the navigation mode the pilot will see his position and heading superimposed on a pre-selected map. In the radar mode he has options for a PPI ground map or terrain clearance information that displays obstacles that extend above his altitude. No date has been set for its introduction. ■

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The first U. S. military operation of air cushion vehicles (ACV), nicknamed "Charlie Victors" by their navy crews, is proving the value and versatility of this new breed of craft. The three armed Bell SK-5s can clear obstacles up to four feet high, hurdle ditches and skim at 60 nautical miles per hour over water, marsh, mud, land, snow or ice on a thick cushion of air forced downward beneath the craft by a horizontally mounted fan. A single 1,000 shaft horsepower marine gas turbine engine drives both the seven-foot lift fan and the nine-foot propeller which provides forward propulsion. All three craft have been undergoing exhaustive test and evaluation, together with their Bell factory-trained Navy crews at the Naval Amphibious Base at Coronado, California. Tomorrow, ACVs could help write new chapters in naval history with the application of its superior capability for a variety of missions including patrol, reconnaissance, rescue and transport.

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Specialized Aircraft Dilemma Grows

Vietnam experience shows single-purpose plane that can be adapted for secondary missions is preferred over general-purpose craft

by David A. Anderton

"WE HAVEN'T FORGOTTEN how to build a simple airplane; we're just not content with one."

The Dept. of Defense Research and Engineering official who made that statement to MISSILES AND ROCKETS was underlining one dilemma that faces planners of future aircraft design. Today, the experiences of limited war dictate a simple airplane for rugged environments. But the targets that must be found, identified and killed are so elusive and so well hidden that the system to do that job must be extremely sophisticated.

The desire to meet the first requirement resulted in the LARA-COIN series of design proposals and developments. The reality of the second requirement has relegated the COIN program to the position where none of the services really wants it (for other than the reconnaissance role), but all agree that it would be fine for friendly forces who don't have the capabilities to support big, complex combat aircraft.

What frequently happens is that these two apparently conflicting requirements are melded into a single specification for a multi-purpose aircraft. But, says the Defense official, there is also a fallacy in that kind of thinking.

OV-10A counterinsurgency (COIN) aircraft developed by North American Aviation for Navy and Marines will also be used by Air Force under terms of a recent DOD decision.

The key point, he stresses, is that generally the airplane which is designed for one specific mission, and then adapted to other jobs, can perform secondary missions better than the all-purpose aircraft which was designed to cope with all those secondary missions in the first place. His argument is that it is often better to develop aircraft to a specific requirement and then to see what else that airplane can do. He cites as one example the conversion of the Boeing B-52's from strategic second-strike systems to tactical first-strike systems without any changes in the basic design of the airplane itself.

In the technology of future aircraft design, the DDR&E official made these points:

V/STOL outlook—The earliest foreseeable operational need for VTOL aircraft is in intra-theater transport. Currently, it is the speed of surface transportation that limits the rates of advance and the depth of penetration. Guerrilla activity along the routes hampers surface transportation even further, and requires guard forces to protect the routes and key distribution points. Air transport can free those forces and allow a reduction in the size of garrison forces, if that air transport can go from one advance area to another. At present, only a V/STOL vehicle looks like the answer.

Right now, the DDR&E official emphasizes, the V/STOL aircraft is about at the same stage as the early automobiles, which weren't much better than the horses they were intended to replace. Further, it is hard to define—under the present ground rules—cost-effectiveness ratios for V/STOL transport. If there is no other way to do the job, the V/STOL route must be taken, even though the cost of that limited effectiveness begins to approach infinity.

About 90% of the missions considered for these applications have a range under 300 n. mi., and not many of them would require true vertical-takeoff capability. The reason is that any site which demands a true VTOL capability generally is within a few miles of a site that requires only STOL capability. The cost of providing vertical capability only—which approximates 10 times the cost of STOL capability—has to be balanced against the actual need. So far, planners have concluded there is little pressing need.

But studies continue on the Air Force's CX-6 V/STOL transport concept. This aircraft is intended to be a cargo carrier in a class with the Lockheed C-130, but capable of VTOL operations. Technically, there appear to be no outstanding problems. Operationally, there is a different situation.

The nature of the intra-theater transport requires that it live in the field with the troops. When there is

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engine trouble, and the engine has to be changed, how do the troops in the field get a ton of powerplant out of a wing 12 ft. off the ground? This is the kind of question that dogs the developers of the CX-6.

Engine programs, said the same official, have matched the development of V/STOL aircraft, and currently we have all the engines needed for these programs. The U.S. continues to fund cost-sharing and knowledge-sharing programs in the V/STOL field, such as the joint U.S.-British lift engine, or the operational trials of the Hawker Siddeley P. 1127.

Aerodynamics hang-up — Aerodynamics is on a plateau, with only an occasional high spot, such as laminar flow control. Here again, the cost-effectiveness ratio is critical. There is no longer any question of the attainability of lift augmentation by boundary-layer control. But for drag reduction, it looks like a thing of the future in spite of the encouraging tests of the Northrop X-21 aircraft. Much has been learned since that experimental vehicle was built and flown, and Northrop and the Air Force want funds now to build a new testbed to capitalize on that knowledge.

No decision has yet been reached on providing such funds, and since the original program was funded by stealing a little bit of money from a lot of programs, there is a great deal of in-house opposition to the project within the Air Force.

One former DOD official compared the Northrop laminar flow control results with those of the nuclear aircraft development program. "It is technically feasible," he said. "The only question is, do you really need the extreme range that makes the development economical?"

Electronics—Third technical area where there is much room for improvement found an echo in similar comments from Air Force and Navy spokesmen: Reliability of airborne electronics systems.

The space program has pointed the way to high reliability of complex and interfaced systems, and there is no reason why the same design techniques can't be used to achieve comparable results in aircraft systems.

Much is being done in systems which are in test or development, but there is none in the field that has been designed with the space-program approach in mind. One promising idea for future use is the fault-finding test equipment now being designed and applied to the airborne systems for quick go/no-go indications down to modular subsystem level.

Need Navigation Aids

OPERATIONS in Southeast Asia, according to DDR&E officials, have shown the necessity for additional aircraft navigation aids at the earliest possible time. The Army is currently using the Decca system in its aircraft and helicopters to provide navigation information over terrain that lacks adequate ground references and for improved all-weather navigation.

Ground-based and airborne equipments for Loran coverage of the entire theater are now being installed. DDR&E also reports that it is now in the final stages of test and evaluation of an improved version of Loran that will also permit the self-location of ground forces in the same coordinate system as Navy and Air Force aircraft.

Officials in South Vietnam report this is expected to provide a significant improvement in accurate navigation required for close-support air strikes. In North Vietnam, the presence of Loran will also aid in the correlation of reconnaissance and subsequent strike missions.

Navy-developed A-7A attack aircraft, built by Ling-Temco-Vought, Inc., Dallas, will also enter the Air Force inventory this year.

AIR FORCE

From the Air Force viewpoint, adaptability of current aircraft designs and versatility for future ones are the big twin inputs to the service from the limited warfare of Vietnam.

No technological breakthroughs are demanded that will revolutionize aircraft design overnight. Rather, the operational experience of units equipped with everything from light aircraft for spotting, to heavy jets for strategic bombing, shows that evolutionary designs can produce the desired results.

There are arguments on both sides. One fighter deployed to Vietnam, and blooded in combat there, has been withdrawn to the United States to lick its wounds. It apparently could not be made versatile enough.

B-52 makes a point—On the other side—a notable success in a technical sense—are the Boeing B-52's of Strategic Air Command.

Whether or not they kill more guerrillas than water buffalo, or splinter more trees than barracks, are moot questions. The outstanding success of the big bomber raids has been the adaptability of the weapon and its deployment in a role completely different from that intended in its design.

Incidentally, observers with long memories remember a striking parallel, when Royal Air Force heavy bombers, not long after their World War II night raids on Berlin, flew low-level daylight raids against guerrillas in Malaysia in the early post-war period.

The B-52's required only a test program to develop the capability to drop conventional ordnance. As tactical bombers, those craft can unload more tonnage of iron bombs over a given area in a few seconds than tactical fighter-bombers could unload on hundreds of strikes spread over many minutes. Further, this load is being dumped in all kinds of weather, by day or night, and from well above the two levels of deadly ground fire.

There is a further advantage to the B-52 strikes. They require no battle-area logistics support. There is no need to clutter the crammed hardstands and airbases of Vietnam any further, and there is no demand for an additional pipeline for fuel and spares and technicians.

But what the B-52 missions really have proved is that the adaptable weapon is a necessity in modern warfare. In Vietnam, the interceptors become bombers, the transports become gun

collage

More Motorola mishmash, continued from page 29

Oh, the glories of us,

or, 259 million errorless bits from an ugly duckling I/C thing.

The ugly duckling image of test equipment (state of the art-wise) will be completely shattered once you've dug our new DTCS (digital test command systems) which North American bought from us to test parts of the Apollo Command and Service Module. These systems use over 125 thousand digital integrated circuits. And, during an acceptance test, they processed more than 259 million bits without mistake, error-wise. In the meantime, we've proved we can build I/C hardware that costs less than, and is more reliable than units using discrete components. Also, each system (North American ordered a *bunch* of them) fits into an amazingly tiny box. Write Western Center on new applications for far-out test equipment, miniaturization-wise.

LEM

A former Caldwell man (Erskine-wise)

Remember when LEM was just the name of some cotton-picking, wench-grabbing Erskine Caldwell character? Now, of course, it means Lunar Excursion Module, and our Chicago group, in cahoots with RCA, will build the test set equipment to check our LEM's transponders. While there isn't much southern decadence associated with this LEM, our people wanted us to tell you the Chicago Center's part will consist of making a phase-lock receiver, a PM transmitter and a transponder simulator. (The spacecraft transponder itself is built at Motorola Western Center.) We specialize in these goodies throughout the division, so if you'd like *your* transponder simulated, write (in confidence) to either Center.

Continued on page 146

platforms, the helicopters become strike aircraft.

Changing pains—The use of these aircraft in roles other than the primary concept in the specifications presents its problems. The Air Force has the same kind of complaints as the Navy voices. There should be more armor and self-sealing fuel tanks. Aircraft are vulnerable to small-arms fire at up to about 4,000 ft., and most of the work is done well below that level. Night and the weather still are complicating factors. Target discrimination is a tough problem. And where is the reconnaissance system that will enable the pilot to spot a small group of men on a jungle trail?

"One big reason we don't have some of these things," said an Air Force colonel, "is because we only got this kind of job to think about five years ago. The military forces are designed on the basis of national goals and concepts, and it used to be simple. We had the job of massive retaliation and the Navy had the beachheads. Then in 1961 the policy changed at a national level.

"We just haven't had the time to go from a complete change of mission to tested weapons systems to do the new jobs. The development life cycle of an aircraft weapons system is longer than five years."

There is also some feeling of envy in the Air Force about the way the Navy has handled the Vietnam conflict with their multi-purpose aircraft. Air Force officers will say that the Navy had an advantage in being on a tight budget during the years that the USAF was getting huge funds to build a missile strike capability. The Navy worked within close budgetary limitations, kept at the beachhead aircraft, and as a result is in better shape today in a beachhead type of war.

This argument may continue to hold true. One looks in vain for the funded Air Force future program that would appear to be sparked by the lessons of limited war. For the near term, that service will buy the Navy's McDonnell F-4 series and the Navy's A-7A series to handle the fighter and attack roles. The North American OV-10A, a development of the COIN program, will also be bought, although some Air Force opinion derides that simpler airplane as not worthy of the USAF.

B-111 limitations—For the longer term, the conversion of the F-111 into the B-111 is not much of an answer to the problems of limited war, at least not so far as cost-effectiveness goes. They are intended to replace the aging B-52 fleet, but their cost is high.

Current targets in Vietnam are so small that they are hardly worth the risk involved in attacking them. The USAF can't long afford to trade an F-105 and its crew for a Viet Cong anti-aircraft battery. It would be even a less economic trade in the future, should F-111 or B-111 aircraft of high cost and high sophistication be deployed in a small-scale war.

Further along, DOD has asked industry to begin parametric design studies which will produce initial data on the proposed F-X fighter and close air support aircraft for the 1970's. This aircraft would be oriented towards non-nuclear delivery, retaining the ability to carry nuclear ordnance in the design. Speeds of Mach 2.5 to 3.0 would be a design goal, with maneuverability to guarantee air superiority.

It keeps reverting back to the same

Unmanned Cargo Systems Tested

TESTING OF THE Ryan Aeronautical Co.'s unmanned flex-wing delivery system continues under Army funding. Objective is to evaluate this unusual system in simulated field and combat conditions.

Parallel work also continues on a towed utility glider using the flex-wing principle, and on a manned version similar to the unmanned system.

The unmanned systems have been tested in Thailand, in an environment similar to that of the Vietnam theater. They are air-launched, and deployed from a packed container by a drogue chute. The flex-wing unit inflates to a 20-ft.-span, 30-ft.-long glider.

The flex-wing systems carry payloads up to 500 lbs., and can deliver that payload within a 400-ft.-dia. circle centered on the target.

Efforts to improve that accuracy continue because in Vietnam a circle that size can easily contain detachments of both friendly and enemy forces.

Current tests use both a homing system and a ground-command link for guidance during the drop. But sink rate is fairly high—one in three—and there is little time to do much controlling after a low-level drop and deployment.

Army is experimenting with other methods of aerial delivery, such as steerable parachutes, with a dual goal in mind. First, the accuracy of drop must be improved. Second, the stand-off distance must be increased.

Circle No. 19 on Subscriber Service Card

problems the Navy and the Army have right now. Vietnam is not the kind of a war any of these forces were intended to fight. Through ingenuity at every level in the fighting forces, these weapons are being adapted to do new kinds of work under new environments; and they are doing it reasonably well.

NAVY

Navy experience in Vietnam has underscored its continuing emphasis on three key parameters of aircraft design: flexibility, reliability and maintainability.

Changing warfare requires flexible weapons, say top Naval officers, and they cite their own observations of fighters being used for ground support, of helicopters being used for attack aircraft today and transports tomorrow, and of the surprise conversion of a docile, aged transport into a guntoting terror.

Reliability is never high enough, they say. The biggest of current bugaboos is the notorious unreliability of airborne electronics systems.

Maintenance, always a tough problem with the carrier Navy because of numerical limitations on personnel, continues to be a problem area. A reduction in maintenance personnel is mandatory, said one admiral.

Self-analysis sought—Right now, Navy maintenance personnel working on complex weapons systems spend about 70% of their time finding out what is wrong, and the remaining 30% fixing it. For that reason, the Navy is interested in self-analyzing systems that tell which component has malfunctioned.

Modular radar systems have improved the maintenance problems, according to the Navy, which cites the McDonnell F-4 aircraft radar as one example of this kind of design. Faults can be relatively quickly traced to a single module, and the module can be replaced by a working unit in a short time.

But the self-analyzing equipment goes the step further, and will provide an important boost to the survivability of the aircraft as well as to its maintainability.

For example, a pilot who knows, before starting his run into the target area, that his radar isn't locking on, and isn't going to, is better able to make the decision that will enhance mission survivability. Should he continue? Or should he hand over to his wingman now instead of having to do so after making the run and not hitting the target?

Survivability—To the list of basic requirements that influence the design of an aircraft, Navy officers place much

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new emphasis on survivability—armor-self-sealing tanks, defensive and offensive armament, twin engines, duplicate and redundant systems, and a host of other design features.

In Vietnam, every rifle, machine-gun and anti-aircraft piece in the vicinity is turned against the aircraft. The heavier shells slam through the armor, because it was designed to a requirement that it stop 7.62-mm machine-gun bullets instead of 20-mm. cannon shells. The wing tanks are ripped open, because the self-sealing features weren't designed to protect against large-caliber weapons.

The hydraulic systems get knocked out with one shot, because—although they were duplicated—in several locations both sets of lines were routed through the same area in the fuselage or wings, and one slug cut both lines.

Missile angles—Missile weaponry trade-offs are another current concern of the Navy. Until recently, the tendency has been to make the airplane heavy with guidance and navigational equipment, and to let the weapon be relatively uncomplicated. Now some Naval officers are thinking that it is time to reconsider the problem and they are talking about a possible need for more complex guidance in the missile and less in the airplane.

Beyond specific systems needs, Naval specialists are looking toward the future types of aircraft they will need to fight this kind of war. Fleet reports are an invaluable input here.

Because the inventory is being reduced by losses in combat and operations, plus natural obsolescence, the Navy is also arguing for increased procurement of such aircraft as the McDonnell F-4 series and the LTV A-7A series. And, in spite of some unofficial dissension in the ranks, the Navy officially is looking forward to the General Dynamics/Grumman F-111B.

There are two principal new aircraft programs in the thinking stage. The Navy VFAX is, from its designation, a fighter-attack aircraft. It will be designed as a multi-purpose plane to complement the F-111B and to provide increased attack capability on short notice. The Navy VSX is to be an anti-submarine warfare aircraft to replace the Grumman S-2 series now in service with the Fleet.

V/STOL? The Navy argues that it has been operating STOL aircraft ever since it got into the carrier business. The catapult remains unique as the world's most-used STOL system. The official stand is that there has got to be a lot of improvement over today's V/STOL systems before the Navy can get interested in them for carrier service. ■

Shore Bombardment Target Location Still Plagues Navy

NAVAL ACTION in Vietnam emphasizes the need to solve problems the Navy claims it anticipated with the close of World War II.

Among the major problems cited are the need for a way to locate shore targets accurately enough for shipboard fire, and the requirement for lightweight shipboard guns able to probe deep into enemy territory.

Other quests call for a flexible air-defense system for destroyers and cruisers as well as for amphibious ships and auxiliaries. In addition, the Navy is in dire need of air-to-surface stand-off weapons. The *Shrike* anti-radiation missile has not been effective in Vietnam nor has the *Bullpup* given Navy pilots much margin for escape once on a missile run.

The difficulty in getting accurate shipboard fire is co-location: knowing where the shore target is with respect to the ship. The ship and the target must be related to a common point. A satellite can perhaps help solve the ship's problem. "But it's damn difficult to tell where the target is unless we send spotters to look for it," said a Navy officer.

Shore bombardment—Although World War II heavy cruisers and battleships are still in the reserve fleet, it is doubtful they will ever see active service because of the large number of men needed to run them. Therefore the Navy is trying to get at least the same capability of fire these ships had without the tremendous cost in personnel and ship size. "We expect to put 1,000 men on a ship for a shore-bombardment job," a Navy spokesman said. This contrasts with the 3,000 men usually needed to run a battleship.

To maintain firepower, the Navy is trying to put big guns on relatively lightweight ships, and increase automation to cut down on the number of personnel needed to fire the guns. For the program to be successful, the guns themselves have to be lightweight.

Specifically, the Navy is trying to get lightweight versions of their standard five-inch gun, and the Army's 175-mm gun. The service would have preferred modernizing its eight-inch gun instead of the 175mm, but this avenue was blocked by the Defense Dept.'s high interest in getting commonality of ammunition between the services as far as practicable.

"We will have to do considerable adaptation of the 175-mm gun," said an officer working on the project, "because of the Army's penchant for weight and other factors peculiar to that service." Nevertheless, the weapon is "now under active development," and the goal is to put it aboard destroyers and cruisers. The 175mm will be the Navy's biggest for shore bombardment.

The program for lightening the five-inch gun and modernizing it is also in advanced development and the weapon is destined for destroyers and cruisers. The fire-control packages for these guns are to occupy less volume and weight than at present, thereby giving the ship less topside weight and better operating characteristics.

Both the large-caliber and the 5"/54 guns will use the new Mk 86 gun fire-control system under development.

The Navy is also looking for shore-bombardment weapons with ranges greater than the 30,000 yards of five-inch guns. This requirement blankets the range of eight-inch guns, which are going out with the large cruisers.

The service is considering using existing missiles for the job as well as developing new ones if present missiles are not adequate. The problem of shipboard fire of missiles is complicated by the motion of the ship and the difficult environment of the sea. "The 3-T surface-to-air Navy missiles (*Terrier-Tartar-Talos*) are not good for conversion," a Navy spokesman said, "but the techniques used to launch them from shipboard can be used for surface-to-surface launchings."

The Navy is developing a rocket assisted projectile (RAP) to augment the range of its guns. In effect, the charge in the gun is RAP's "first stage," and the RAP rocket the second stage.

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Reconaissance photo shows convoy of trucks in North Vietnam waiting to cross makeshift ferry where bridge has been bombed out. New weapons such as Walleye are well suited for taking out bridges while reducing danger to attacking aircraft.

Currently in engineering development, RAP's main use will be to support the work of Army helicopters up to the time Army artillery comes in. In this critical period, the only effective support the helicopters can get is from shipboard fire. And the range of this fire determines how far inland the helicopters can go.

Bombardment rockets—The Navy needs a way to neutralize a beach area just prior to assault. During World War II, landing craft converted to rocket ships could launch many waves of rockets, neutralizing a beachhead. But after WW II, this country's strategic buildup neglected the equipment needed for beach assault. The Navy only recently reconsidered and is now trying to bring the rockets to the present state of the art.

Five-inch unguided rockets were used in WW II, but these can be improved both in terms of warheads and propellants. "It's no problem," said a Navy spokesman, "just a matter of putting money into the work." The Navy is also seeking faster ships to launch these rockets because the rocket carrier of WW II was slower than the modern amphibious ship.

The Navy is about to flight-test the Army's *Lance* missile in a sea environment to learn the weapon's usefulness in supporting landing forces. *Lance* is a battlefield support weapon. This work, budgeted at $2 million for Fiscal Year 1967, is part of the Navy's landing force support weapon (LFSW) program.

Shipboard air defense—In search of a way to give its combat ships a "close in" air defense system, the Navy is experimenting with a short-range ship-based version of its air-to-air *Sparrow* missile. "Preliminary test and evaluation has produced encouraging results," Defense Secretary Robert S. McNamara told the Senate subcommittee on DOD appropriations several weeks ago.

The Secretary said that the *Sea Sparrow*, air-defense system, as it is named, could also be installed on amphibious ships and auxiliaries that up to now are protected from air incursions only by guns.

The FY '67 budget has money to develop this point defense surface missile system (PDSMS). A more sophisticated system under consideration would draw on some components from the Army's cancelled *Mauler*, according to McNamara.

Despite the work going on it the "Get Well" program, the Navy is still eager to replace the *Terrier-Tartar-Talos* "3-T" missile systems.

First step will come with procurement in FY '67 of the new standard missile designed to operate from *Terrier* and *Tartar* launchers with a new and improved *Tartar-D* digital fire-control system.

Beyond this is the Navy's *Advanced Surface Missile System (ASMS)*, which could see service in the early 1970's if development is successful. It is designed to be a very-long-range system with capability against evasive, high-performance aircraft operating at all altitudes. Because DOD is highly interested in the degree of component and technique commonality that can be developed for *ASMS* through the Army's *SAM-D* program, already under way, *ASMS* will remain in a very early development status for at least another year. The program has been funded at $2 million in FY '67.

Air-to-surface missiles—Although the Navy has been almost the sole innovator in this category for several years, there remains an urgent requirement for effective guided weapons able

to operate from stand-off ranges beyond defensive perimeters. Much new emphasis has been placed on electro-optical and radiation homing systems, and there are new programs under way. More effort is required, however, to expand this capability to night and all-weather operations.

Condor, a long-range TV-guided stand-off weapon, and *ARM-1*, an advanced radiation-homing missile, are both moving into development (M/R, Oct. 18, p. 18; Jan. 31, p. 17), but their deployment is several years away.

In the interim, the Navy-developed *Walleye* TV-guided glide bomb, also to be used by the Air Force, will go into combat inventories in about 12-18 months. *Walleye,* upon which most of the advanced electro-optical guidance systems are based, will provide some stand-off capability against hard, but lightly defended, targets.

There is a major effort now under way to improve the performance of the first-generation *Shrike* anti-radiation missile. The project includes an attempt to quickly remedy the existing bird's problems, and an evaluation of other available missiles that could be fitted with radiation homing devices. ■

Need for Accurate Missile Guidance Systems Emphasized

by Rex Pay

China Lake, Calif.—Scientists at the Naval Ordnance Test Station here say that once the basic, but very difficult, problem of finding the target has been solved, the major facet of missile design that needs to be improved is the development of accurate guidance systems.

No breakthrough in the state of the art is required in missile technology, they maintain, simply the application of time and money to the specific problems of limited wars. Chief among these is the need for high accuracy.

For unguided ballistic rockets fired from aircraft, the chief problem is that the aircraft is a flexible and deformable structure. It has to be if it is to be lightweight. Not only does the flight line not stay fixed, but no two points on the aircraft stay in fixed relationship to each other.

Calibration gremlins—A hard landing will cause a slight bending of the wing, meaning that the datum line through an unguided missile no longer is precisely aligned with the pilot's sighting mechanism.

This sort of problem occurs in other forms, too. For example, there are some sight systems that make use of the cockpit windows to carry a reference marker or its reflection. These are made inaccurate by the fact that cockpit windows bend a degree or a degree and a half of arc.

It is problems such as these that people forget, say Navy technicians, when they try to line up a weapon in an aircraft's bomb-bay within a couple of thousandths of an inch of an aiming device in the cockpit. The Air Force has a real problem in attempting ballistic delivery.

Ships are better in this respect than aircraft, but they still suffer from the same problem. The submarine is the least affected when it is submerged.

As far as other-types of missile design is concerned, scientists here say there has been a temptation in the past to attempt to develop a general-purpose missile that will meet all requirements. In the absence of strong pressure for tactical missiles for operational use, this pressure is hard to resist.

Propulsion considerations—There are no outstanding new requirements in the area of propulsion. Exhaust plumes can give problems, but these are by no means insurmountable. Many people call for more range. But designers point out that it does not pay to carry propulsion for range greater than the distance from which you can locate the target. "People do not appreciate the cost of extra range. If you double the range, you have to have eight times the propellant."

If you can afford to pass over your target before the missile hits it, you do not need propellant. Thus *Bullpup* has to be propelled (being commanded to the target), whereas *Walleye* does not. Absence of propellant means that a greater explosive payload can be carried.

Walleye has a television camera that is focused and positioned on the target by remote control by the pilot. Once the target has been acquired by the camera system, the equipment in the bomb takes over and steers the bomb to the target. There is no command link to the bomb and its vulnerability to countermeasures is greatly reduced.

In essence, *Walleye* uses a similar technique to those employed in ground-based television trackers used to position cameras photographing missiles. In these, a high-contrast edge on the target is positioned within a window on a television display and movement of the edge away from this window generates an error signal. This error signal drives the camera in a direction that reduces the error and brings the target back into the window.

In systems such as this, it is not necessary to position the window of the display over a physical edge on the target; the bomb can be directed at the boundary of a shadow. Thus such a weapon can hit the center of a target, provided there is optical contrast there, even though it is an edge tracker.

Extension of the range of *Walleye*-type weapons, insofar as this is limited by the guidance system, is possible out to the point at which turbulence intrudes into the television image.

Scientists here believe that *Walleye*

is the answer to the problem of hitting targets accurately in daylight, when they can be seen. It is ideal for bridges.

Night sighting—For night-time attack of targets with similar high accuracy, some here believe that a system covered by a patent applied for in 1953 by NOL scientists is still one of the best solutions. It is a simple system that was shown to be feasible in tests at NOTS in 1951. It has not aroused interest in the Pentagon, perhaps because it needed no further development. It uses available hardware.

One of the problems of attacking troop and vehicle concentrations in darkness is that when flares are dropped to allow attack by conventional aircraft weapons, the delay between these two actions allows the target to escape.

The NOL weapon proposed is a radio-controlled drone, missile, or glide bomb equipped with a narrow-beam searchlight in its nose, pointing straight along its flight path. The controlling aircraft stands off and steers the weapon to the target by making it illuminate the target with its searchlight.

To hit several targets at once, several aircraft can each drop and control a weapon. The simplicity of the weapon means that one aircraft can carry several of them. An aircraft landing light could be used as a searchlight. ■

Army Engaged in Painstaking Search for New Small Arms

THE ARMY is nearing completion of a high-priority program called the Small Arms Weapons Study (SAWS), established for the primary purpose of choosing a new basic infantry weapon family.

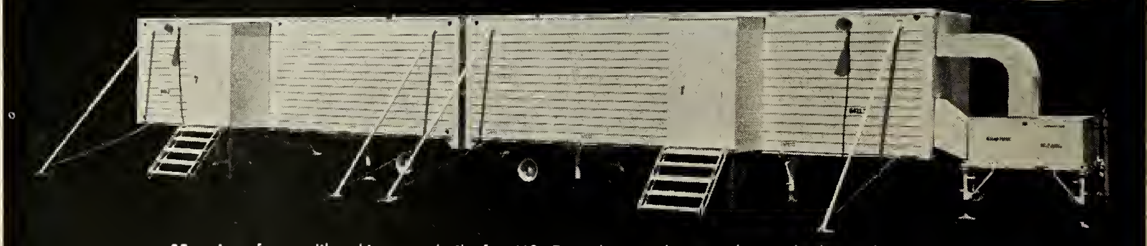
This study involves "everyone who could remotely contribute," says one Army official. Dr. Thomas P. Cheatham, Deputy Director of Defense Research and Engineering for tactical warfare programs, says that no participant will be able to call "foul" with respect to this evaluation.

Cheatham was instrumental in setting up SAWS in the first place. The program involves candidate weapons systems—including the Army's new Special Purpose Individual Weapon (SPIW)—supplied by industry and Government sources.

All small arms, mortars, recoilless rifles, grenades and small-point-target rocket launchers are offensive weapons and must operate under coordinated, group fire situations. These also mesh with larger weapons such as artillery, missiles and aircraft-delivered stores. SAWS is a concerted, integrated attempt to tie small-arms weapons, tactics and training to the larger echelons of fire now available to the U. S. Army—while incorporating the particular problems faced by troops in Vietnam.

The result may be one weapon for a rifle, another for a machine gun, or one family capable of handling both. Or it could be a diverse arrangement.

TRAILERS FOR THE SPACE AGE by DORSEY



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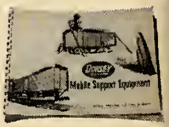

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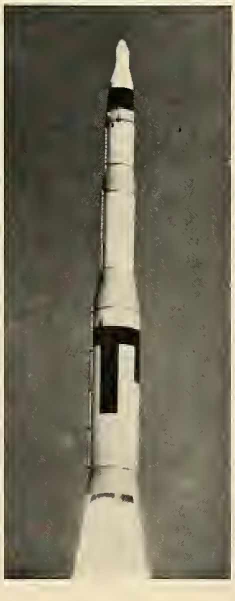

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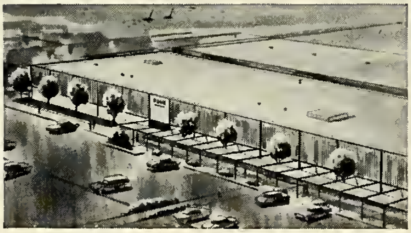

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Stringent evaluation—The candidate systems are being evaluated in the light of every known factor—from production through the immediate inputs from Vietnam. But the Army is reluctant to describe publicly, in detail, the weapons themselves, the tests involved, the weights assigned to various parameters, or the methods used to match small-arms function with other ground and air weaponry.

The Army commands, laboratories and arsenals involved in SAWS are operating under the scrutiny of DOD personnel already familiar with the nerve-wracking evolution of the M-14 rifle. The determination not to repeat this cycle is evident.

In the running—The weapons under consideration include:

- SPIW—a special-purpose infantry weapon designed to couple a sure-kill, small-caliber shoulder-fired piece with an area-fire weapon. The latter function is normally associated with a grenade launcher. Small darts, sabot-fired, are known to be under consideration as the rifled or small caliber element.

As an infantry weapon, SPIW is revolutionary in that it is meant to provide both functions almost simultaneously.

Prototype SPIW units have been developed by Aircraft Armaments, Harrington & Richardson, Winchester-Western, and an Army in-house team at Springfield (Mass.) Armory. The Army has selected the Aircraft Armaments and Springfield Armory versions for further development and has ordered prototypes for evaluation.

- The Stoner 63 systems—consisting of assault rifle, carbine, light machine gun, medium machine gun, fixed machine gun, and light, belt-fed machine gun. All of these weapons have at least a 78% parts interchangeability, and, in some cases, 100% commonality among the family.
- The Colt submachine gun and the heavy assault rifle.
- Armalite's AR-18 rifle. (All of the weapons covered to this point evolved from the original Armalite AR-15 development. Colt bought the rights to certain Armalite developments and Eugene Stoner was originally one of the innovators at Armalite.)
- Harrington & Richardson's T-223 rifle, a modification of the German G-3.

The M-14 is also involved, and so, probably, are other innovations within the Army arsenal complex.

Vietnam experience—With the exception of the priority associated with SAWS, the Army's current arsenal of weapons in Vietnam is meeting requirements, and there only a few other urgent major programs under way.

Improved mortars are in the development cycle—among them a 107-mm unit designed to replace the 4.2-in. heavy mortar. This weapon is lighter and has a greater range than the 4.2, but maintains the same lethality.

There is some research and development work going on in component and ammunition improvements all down the line. Most of the details are classified.

There is no armored combat in Vietnam, so there is little Vietnam-induced urgency for new anti-tank weaponry. Army combat veterans are eager to try out the current inventory but the Viet Cong has not yet provided a target.

The most effective small-arms weapon now in use is the XM16 E-1 automatic rifle. Developed originally by the Armalite Div. of Fairchild-Hiller in 1957 and now manufactured by Colt, the rifle owes much of its success to the invention and perfection of the first small-caliber, high-velocity ammunition round in military history—the .223 (5.56 mm) cartridge.

The military-industrial interface in the development history of this weapon is a series of almost unbelievable events. It passed tests with the wrong ammunition, and, in one instance, after lost parts were replaced by cotter pins and welding wire.

It is still regarded as an experimental rifle because the standard Army weapon is the M-14 rifle using the 7.62 mm cartridge. The development cycle of the M-14 kept the Army under sustained attack from industry, Government and allied nations for almost 20 years.

The M-16 has been further improved by a modification that adds the 40-mm grenade launcher to the weapon to provide a point fire/area fire unit in the field. Army units in Vietnam are now being supplied with this combination.

A production run of 100,000 M-16 rifles is in progress and will be used to equip the First Infantry in Vietnam, replacing the M-14 weapons. ■

Air Force Turning Attention To Better Tactical Support

by Charles D. LaFond

NEW AIR FORCE WEAPONS for the 1972-1975 period will be designed to provide pilots in limited-warfare situations with all-weather capability for large-payload, stand-off delivery systems and low-cost propelled small missiles permitting low-level air-to-ground saturation bombardment.

Turning its eye from a former concentration on strategic weapons systems, the Air Force has found a serious gap in its tactical support arsenal and is increasing R&D efforts to close the fissure. Too long dependent on Navy-developed systems, the Air Force now finds itself short on talent, time, and optimized weapons for its tactical ground-support operations.

AF R&D, past to present—The present lack of a flexible, multi-punch arsenal of effective air-to-ground weapons is explainable but hardly pardonable. Throughout the 1950's, the Air Force developmental groups exhibited a marked and general preoccupation with R&D centered on strategic weapons and delivery systems. Also, the emphasis was on nuclear rather than conventional warheads.

It is true that AF officers were aware of, and in some cases, deeply interested in the ultimate need for smaller, tactical, conventional-explosive systems. The Air Force, however, chose to buy, not develop. As pointed out by one high-ranking DOD civilian official, less than one-quarter of all Air Force R&D expenditure in the past has been for non-strategic systems R&D. Of this amount, most was used for aircraft and associated avionics research efforts.

In one category, the Air Force did expend some effort—air-to-air missiles, or more specifically the *Falcon* series. This, however, typified the parochial trend within all the services, a tendency to possess that which is absolutely needed to protect or promote the primary efforts of that service.

U.S. airborne missile work in general has been geared much more to development of air superiority and air defense missiles to oppose a Soviet bomber threat, or threat to the fleet, than to air-to-ground weapons.

In Vietnam, a real air threat has yet to develop, although one may in the near future, depending largely on the whim of the Red Chinese hierarchy.

Another factor that has inhibited work in the past has been the traditional aviator's preference for flying down a gunner's throat with a bomb rather than yelling for help. Recent interviews in Vietnam with flyers of all services now turn up strong support for stand-off weapons.

Borrow Navy—In Vietnam, all airborne missiles, including the *Bullpup, Shrike, Sidewinder* and *Sparrow,* are Navy-developed. Furthermore, the follow-on generation of weapons that eventually will appear on the scene will also be either Navy-developed or based upon design work originally done by the Navy.

The *Zuni* and 2.75-in. unguided rockets used effectively by the Air Force in Vietnam against a variety of ground targets are also Navy developed.

The demand for the 2.75, especially with new high-fragmentation warheads and instantaneous fuzing, has been so great that production rates of rocket-motor casings have been greatly increased. Fuzing and arming device production, reportedly, is still the clinker in increasing usable rocket output to the same level.

Great difficulty apparently exists today in obtaining good reliable statistical data from combat pilots. It is from such data, methodically collected, "massaged," and evaluated that system needs or improvements can be more effectively determined and solved or implemented. The communications channel from the user to the developer has been poor, say Pentagon spokesmen.

A partial solution to the problem is the stationing of a sizable number of R&D experts in Vietnam, capable of observing first hand the operational effectiveness of weapon systems and evaluating new systems.

In the meantime, sufficient knowledge has been obtained concerning the lack of effective hardware in certain areas to pursue a program for improvement and to expand rapidly a relatively slow-moving four-year effort by the Air Force to develop new weapon systems.

Conventional ordnance—There exists today a re-emphasis on the use of conventional ordnance and munitions employed and delivered by aircraft. Automatic guns and cannon, in a sense, have been rediscovered. It has been found that such weapons, which include the 7.62-mm Minigun and 20-mm Vulcan "Gatling" guns, complement all air-to-ground operations despite the fact that they generally have not been optimized for such use. Nevertheless, such weapons were highly developed and used during the Korean War and have again earned user respect.

Improvements for such weapons are now centered on the ammunition, rather than on the guns. These include better fuzes and fuzing techniques, improved projectile hardness for armor or reinforced-structure penetration, and increased velocities for the air-to-ground application.

Because of the short time-on-target experienced by high-speed jet aircraft, the Vulcan has provided a great assist against ground targets with its 6,000 round/sec. firing rate. But for slower craft such as A-1's and even the venerable C-47, the Minigun (with its similar firepower) has proved to be a great equalizer against small-arms ground fire.

The resurgence of interest in the more conventional weapon stems from its reliability—on the order of 0.9999, a figure unheard of in the unguided or guided missile field.

Despite this, there is considerable activity being pursued in the development of higher-caliber guns, tube- or rifle-launched grenades, or projectiles powered with integral propellant charges. Such weapons, say Air Force officials, offer some distinct advantages, but are about 2-4 years away from practical development.

The "iron" bomb—The gravity bomb, too, has seen a rebirth in the Vietnam effort. For years, the emphasis has been on improving accuracy and range in weapons systems. Now it has been found that such attributes offer little in effective payoff when the target location is known only generally and is covered by a massive foliage canopy.

Thus the expenditure of large numbers of conventional bombs in a saturating pattern provides a many-fold increase in cost effectiveness, particularly from high altitude. The cost of aircraft lost to ground fire can often offset any cost-effectiveness argument in low-altitude operation. But, said one official, "it's the only approach we have for close-support of ground troops."

R&D for such bombs is now centered on improving lethality by controlling fragmentation or widening the kill area. The urgency of providing fuzing options to the pilot is still of major concern (see p. 47).

The problem of providing the pilots with an electrically set fuzing option in flight is being studied by the Air Force, but a satisfactory early solution appears doubtful, DOD officials say.

To bypass the hazards of low-level bombing attacks, the Air Force has for some time been developing and is now testing an upward bomb-ejection system at Kirtland AFB in Albuquerque, N.M. Such an approach will improve bombing accuracy and provide more time for the delivering aircraft to avoid blast effects from the ground.

Hundreds of water-filled craters leave vivid tracing of B-52 strike with 750-lb. bombs against Viet Cong jungle targets 20 miles west-northwest of Bien Hoa, Vietnam. Photo was taken by cameraman aboard Skyraider during later combat mission.

A gas-ejection system is employed, similar to that used for pilot-seat ejection, which accelerates a 340-lb. load to a speed of 100 fps with an 18-in. ejector-system stroke, according to Air Force developers. A retardation chute is used with the bomb to reduce forward and descent velocities.

Another new development, also from Kirtland AFB but in the support area, is a new bomb-handling dolly called SEALS, for stored energy actuated lift system. The four-wheeled dolly is being considered as a means to simplify the movement, storage, and loading of bombs into or on aircraft. It would join its associated bomb probably at an arsenal at its first storage point and then stay with it through eventual shipment, restorage, and eventually right to the aircraft. At time of loading, a solid slow-burning propellant charge would provide necessary gas to activate a pneumatic lift assembly. Lift capability to 7,000 lbs. is considered practical.

Bomblets and dispensers—The use of aircraft-attached pods or dispensers for the containment and subsequent pattern ejection of large numbers of small aerial bombs or bomblets has been a very effective weapon in Vietnam. Typical of these is the SUU-7 dispenser system carried on the outboard station of Air Force fighter-bombers. The SUU-7 employs ram air to eject the bomblets rearward. Pods are disposable and are not reloaded.

There has been some strong but not widespread argument against the rearward release of bomblets since, under some conditions of speed and maneuver, the weapons can strike the undercarriage of rear aircraft assemblies. To solve this problem the Air Force is developing a downward ejection system using squibs for the downward thrust.

Another approach to the dispenser/bomblet concept is a system now under developmental test on the sled track at Holloman AFB, N.M. The new bomblet, developed at Eglin AFB, is a small cylindrical anti-personnel weapon equipped with a paraglider—a small flexible lifting surface apparently made out of fabric. A dozen or more bomblets are contained in a long tube carried by low-flying aircraft. As each bomblet is ejected from the tube, the paraglider deploys and floats the weapon down to the ground. Air currents and variations in parasail deployment ensure dispersal of the weapons so that they cover a wide area.

Guided bombs—The only guided bomb now being seriously considered is the *Walleye*, under development for the Navy. The Air Force states that it will use the system when operational but it has no plans to press for development of any other similar system at this time; however, it would prefer an all-weather capability.

It is doubtful that *Walleye* will replace *Bullpup*, now in use by all services; rather, Air Force officials say, the glide bomb will complement the missile.

They do admit, however, that the *Walleye* stand-off capability will assure its assuming a stronger role for future use than *Bullpup*.

Missile systems today—For tactical use, the Air Force today employs unguided rockets and the *Bullpup* visual/radio command guided air-to-surface missile. It has purchased *Shrike* anti-radiation homing A/S missiles, but these have not been employed operationally. Also Air Force officials have declared an intention to buy, when operationally available, the new *Condor* electro-optically guided stand-off missile (40 mi. range); the *ARM-1*, an improved-range and, it is hoped, a more versatile anti-radiation missile. All are Navy-developed air-to-surface weapons.

Under Fiscal Year 1967 funding, the only Air Force A/S weapons system, the *Maverick*, will enter the developmental train (M/R, Dec. 6, p. 14). Officially called the AGM-65A, the new TV-guided system is expected to provide a new market approaching $100 million. The development-to-production cycle for the weapon is expected to be short—on the order of one year after initiation of the usual program definition phase. This brevity, however, is based on the assumption that some long-lead time items will get early development.

Its operational use will be directed to F-4C, F-5, and F-105 aircraft.

Key to favorable nods by DOD for *Maverick* development apparently is a highly successful flight test program of a prototype TV-guidance system at Eglin AFB last year. The electro-optical package used was developed by North American Aviation, Inc., and is based somewhat on *Walleye* and *Condor* guidance concepts and experience.

Capable of carrying a smaller warhead than *Bullpup-B*, *Maverick* will provide stand-off capability against hard-point targets, with an effective range comparable to that of *Walleye*.

One other possibility exists to extend the Air Force A/S weapons arsenal for tactical use—the *Short Range Attack Missile* (*SRAM*). Presently being developed as an extension of the strategic offensive arm, *SRAM* could be used, with flexible guidance, in a tactical support role. Such an application has been discussed before Congress in recent testimony, but it is apparent that no deci-

Air Force F-4C Phantom rolls in on dive-bombing run against target in mountains of North Vietnam. This aircraft was the most extensively used last year for night strikes against the North. Pilots now are expressing more interest in stand-off weapons.

sion has been made yet to give the missile such a dual function.

As a matter of fact, no decision has been made to date as to the ultimate kind of guidance system to be used by *SRAM*. It will be developed for use with an inertial guidance subsystem and space will be provided, reportedly, for a terminal homing subsystem in the forward missile section. Thus, it is possible that a variety of homing devices might be employed for different needs.

Future missile needs—Two general types of weapons are needed by the Air Force and both are being studied vigorously: an all-weather follow-on to either the *Walleye* or *Bullpup* carrying comparable payloads; a smaller-payload missile, at low unit cost, permitting large usage rates with relatively high accuracy. Both are needed now, but such systems are not expected to be ready for use until 1972-1975.

The former will preserve the *Walleye/Condor* capability to apply large payloads against large defended hardpoint targets but will obviate present design limitations. Tactical air support should not have to be postponed because of weather or darkness.

The latter need has been learned in Vietnam also.

Saturation bombing from high altitude has proved valuable there against concealed targets and where high delivery accuracy was non-essential. For close support of ground troops, low-level bombing attacks require a finer precision—a technique that exposes aircraft to lethal ground fire.

Salvoed missiles, fired with a nearly straight-line trajectory from somewhat higher altitude, can provide at least a partial solution to the problem, according to some DOD experts.

Behind the scenes, however, an argument persists among both Air Force users and developers, with both sides split in opinion—whether the Air Force should develop families of weapons providing a variety of operational options through special-purpose implements or develop more all-purpose weapons.

Ignoring the use aspects, the argument centers on cost-effectiveness. Special-purpose weapons offer higher performance but create greater logistical problems. All-purpose weapons control the extent of inventory and offer the opportunity for eventual cost reduction through quantity purchases. Both approaches produce varied and uncompromising arguments concerning training and maintenance problems.

No solution appears near, or even probable, say DOD officials, and the expected decision will be for a continuation of the present weapons mix.

Detection and guidance needs—Future weapon system effectiveness must rely to a very large extent on development of better target detection and location systems for aircraft and better missile/bomb guidance.

All the accuracy conceivable in an air-launched weapon is meaningless unless a way exists to first detect and locate the target.

For years, the emphasis has been placed on aerial reconnaissance and surveillance by the Air Force—and with good reason. Airborne sensors—photographic, infrared and side-looking radar—have been used effectively to detect and pinpoint such targets as troop movements and relocation, vehicles in concealment and material storage depots.

Also, repeated aerial surveys provide film storage of sensor data which assures a means for comparison of pictures. Thus, for example, a landscape change can signify occupancy. This need will always exist. But, it also creates massive data interpretation and handling problems and the evaluation of sensor data is not in real time.

Digitally annotated recon film data have speeded up the process. New techniques now permit some computer analysis. But the time is still too long between data gathering and ordnance delivery.

Furthermore, the need is just as valid for night and bad weather operation.

It is in these areas of need that considerable research is being expanded today by Air Force R&D centers.

Low-light-level image orthicons operating in the visible or IR range may produce improvements for cockpit displays. Improvements may be found by providing real-time readout of side-looking radar-developed images.

Also, the use of the laser as an illuminator may prove feasible. So far it is being looked at primarily as a range finder or as a cooperative illuminator for electro-optical missile homing.

In truth, however, none of these approaches (and there are many others being examined) appears particularly productive at this time, with the possible exception of low-light-level TV. In general, limited sensor resolution combined with losses in cockpit display produce a poor output to a pilot who must also control a high-speed aircraft, possibly over hazardous terrain.

Thus, there is considerable emphasis on improving methods of inertial navigation to assure that the aircraft is in fact going to reach a predetermined target location. For night operations, reliance is, as it has been through several previous wars, on ground or aircraft illumination of targets using flares. Improvements are being sought to provide better ejection and dispersal of flares from aircraft and to improve flare-descent retardation, flare intensity, and burning time.

Guidance improvements—Admitting that all-weather operation against ground targets is just not practical today or in the near future places continued emphasis on pilot eyeball techniques or on the use of some target-generated homing mechanism. The acceptance of this fact of life by the Air Force explains the present emphasis on electro-optical guidance techniques and on anti-radiation homing systems.

The first assumes that the pilot can see his target long enough to draw a bead on it and thus permit his missile or glide-bomb guidance to similarly acquire the target before firing. The second assumes that the enemy electromagnetic radiator will serve as a beacon to guide a missile.

Electro-optically guided systems date back to the World War II AZON, RAZON, and TARZON guided bombs used in Europe against clustered hard-point targets with limited success. Since then, *Walleye* and *Condor* are the first attempts at more sophisticated guidance systems combining eyeball with electro-optics.

Optical-image area correlation systems employing pattern recognition techniques appear very fruitful (both Martin-Orlando and Goodyear Aerospace have made significant hardware developments recently).

Several approaches using laser guidance techniques are under development. One employs a pulsed beam from the delivery aircraft, much like conventional radar guidance, to actively direct missile flight. Another employs a separate slow-moving aircraft as a target illumination laser source Missiles home on target-reflected optical radiation. A third approach would put the laser illumination in the missile but limited output power and receiver sensitivity appear as unsurmountable problems at this time.

Passive guidance techniques employing natural spectral radiation from ground objects may prove out in time. The microwave range as well as the visible and IR portions of the spectrum are being considered.

Increased emphasis is being centered now on the use of infrared guidance against ground targets from the air, but the problem is difficult because of natural ground radiation clutter. Careful selection of target radiation bands might help, and there is increased interest in the use of IR mosaic detectors operating with the longer IR wavelengths. Both appear particularly useful against vehicles and ground structures.

Radar, because of its near-all-weather operational capability, continues to offer a good guidance potential The lower frequencies provide a built-in potential for use against targets concealed under jungle canopy. ■

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Surveillance Needs Systems Approach

Army experience with elusive enemy in Vietnam points to lack of precise requirement definition for target-detection systems

by John F. Judge

THE U.S. ARMY is now struggling to establish a systems approach to the ancient problems of ground tactical combat surveillance and target acquisition.

The task, they admit, is difficult, much more so than in applying systems thinking to weaponry and its associated tactics. Part of the complexity lies in the classically diverse functions existing in an Army—the rest of the problem has to do with the enemy and his environment.

The target is intelligent, mobile and thoroughly familiar with the combat environment. There are no battle lines, and 360-degree perimeters are the rule rather than the exception. If the conflict in Vietnam has any characteristic in common with future "liberation" wars, one element will be that the battle is where the people are instead of fixed geographical areas.

Willis M. Hawkins, Army assistant secretary for R&D, says candidly that the service itself must recognize its obligation to effectively state the problem before any workable systems approach can be initiated.

Merely locating and identifying the enemy is not enough. The field commander must anticipate his opposite number's moves—on an hourly basis or better.

Specific responsibility—"In the Army," Hawkins states, "we have recognized that we are, in fact, the only organization that can write the requirements for these systems. We are the ones who demand the information and who must react to it. So far, our definition of these requirements has failed to be a real definition and we must recognize our responsibility to do something better than the routine listing of everybody's desire for information as a basis for requirements."

Infantrymen use AN/PPS-4 combat surveillance radar set now operational in Vietnam. The 115-lb. unit will be replaced by lighter AN/PPS-5, with visual and audio output.

The Army has attempted to develop many military tactics through the use of operational tests, but not in the surveillance and target acquisition function, charges Hawkins.

Hawkins is also tough with industry—suggesting that a closer look be taken at their gadget peddlers. He points out that the Government is not immune to strong sales efforts and has too often succumbed to clever but basically useless ideas.

Hawkins charges industry with the responsibility of becoming as conversant with the problem as the Army itself. A starting point, he says, would be a persistent and intelligent questioning of requirements which seem illogical. Such a dialogue may provide analytical insight within the Government to correct errors of concept.

Hawkins also brings DOD into the field of fire.

The aim, he says, must be to think of the surveillance and target acquisition problem in terms of capabilities of officers who command tactical units at the lowest level—yet so conceive the subsystems that they fit well into federated systems of larger capability.

The Army secretary says that no matter how carefully we plan, or how thoroughly we organize our analysis, the facts of any tactical situation are bound to cause the commander to "make do" where he has not been provided the tactics or the equipment.

This means that the creation of combined unique systems which exclude overlapping, simpler systems—and which might be thwarted either by events or an ingenious enemy—must be avoided. "The Dept. of Defense is the one truly responsible here," he says.

The concept of tri-service systems eventually drives decisions up in the military organization—a situation Hawkins feels must be specifically avoided in surveillance and target acquisition. The opposite effort must be made—push the decision lower in the echelon.

Hawkins claims that sensor develop-

Rifleman lines up reflector of an AN/PPS-5 surveillance radar. The forward area unit is expected to be in Vietnam this year.

Army sergeant sights through image-intensifying scope, first of a family of such devices using natural night light.

ment has lagged reconnaissance vehicle development. Both have preceded logical creation of overall combat reconnaissance system concepts. In this, there is general agreement throughout the cognizant Army sections in the Pentagon.

Details overstressed—Hawkins insists there has been too much concern with details instead of considering the entire problem, and that there must be a return to a concept of handling only essential data. To continue escalating the gathering of information even though we can conceive of many ingenious ways to sort and display it, is futile, he says.

With respect to specific services, Hawkins sees gains in better use of existing hardware. The Army now has reasonably effective infrared systems and new ones coming along which will seek smaller targets and longer-range performance. The radar systems have the beginning of a useful intelligence filter in the use of moving target information (MTI).

Hawkins suggests some kind of correlation between MTI and infrared or with information from other sources such as polarization of the radar return, and microwave radiometric measurements, or from the visible spectrum of the target.

Another technical scheme that might be used in some kind of correlative system is the sampling of air. Devices to do this are emerging from the laboratory. The importance of such a capability utilized by either the infantryman or the crew of the aircraft is not yet determined.

Hawkins points to one specific correlation and filter scheme now nearing the end of its development phase and slated to be moved to Vietnam in the near future. This is VATLS, or the Visual Airborne Target Location System.

This system involves an airborne observer equipped with a telescope mounted on an inertial reference platform. The aircraft is ground-tracked.

Transmitted to the ground are the elevation angle, azimuth, altitude and range, relative to the aircraft, of targets sighted by the observer. The tracking system closes the loop by locating the observing aircraft and determines the accurate location of the target.

While moderately complex, the system has the advantage of maximum simplicity in data handling since it relieves the commander of any filtering task. The system can by-pass the commander and be linked to artillery or used to call in air strikes.

Hawkins says there are many subsystems now in the field not directly linked together for mutual support. Such hook-ups lead to the combined systems or "federated" approach. But he warns that any combined systems thinking must include the individual effectiveness of the subsystems as the case determines. Too thorough an integration solves nothing.

Visual surveillance—The most dependable means of ground surveillance is still visual observation. All the technological advances made to date have not improved upon this rather risky method.

The individual trooper can now extend his visual acuity, especially at night, with a host of small devices based on image intensification. Even the blackest night has some light and this is being utilized in the creation of small, hand-held, passive instruments. Equipment such as improved telescopes handle the daylight environment.

There are also a variety of powered items ranging from microwave radar through the infrared. For instance, there is an IR image metascope—a 2-lb., hand-held near-IR viewing device with a small accessory IR light source.

With its own light source, its range is about 15 meters and it can detect enemy IR up to 10 miles. The viewing range can be extended when coupled to high-intensity light sources such as searchlights.

There is in service an IR weapon sight intended primarily for night target location and aiming. It can be used on or off the weapon and, with its light source, weighs 11 lbs. Its range is 300 meters with a 4.5 magnification.

There is a helmet mounted near infrared binocular weighing 2 lbs. with a range of 50 meters. Its primary use is to allow driving at night at normal speeds through the aid of infrared-filtered headlamps.

The principal radar equipments assigned to infantry, mechanized and tank units, as well as armored cavalry squadrons, are the AN/PPS-4 and the AN/TPS-33.

The PPS-4 is a short-range radar unit weighing 115 lbs. with the ability to detect moving personnel up to 3,500 meters and vehicles out to a range of 6,000 meters. Moving targets are heard on a headset.

The 250-lb. TPS-33 is a medium-range radar set used to sight moving personnel at 5,000 meters and moving vehicles at up to 18,000 meters. Display is both audio and visual.

The AN/TPS-25, located in the headquarters battery of division artillery, has the same ranging ability as the TPS-33 but with the inclusion of deflection, range and elevation of the radar linked to an indicator.

There is also a direct support artillery battalion radar, the AN/MPQ-4, designed to locate enemy weapons by detecting the trajectory of mortars and high-angle artillery having a minimum caliber of 60 mm.

Improvements underway—There are improvements in the mill on all these radars—the one closest to operational use is the AN/PPS-5, designed to replace the PPS-4. The new infantry radar set weighs only 56 lbs., can be operated by one man, and has effective ranges to 3,000 meters for moving personnel and 10,000 meters for moving vehicles. Display is both aural and visual.

There is also a new moving target information kit, referred to as the beginning of a useful filter by Hawkins. Now in the bid-evaluation stages, the kit will allow radar units to distinguish mortars from such things as rain squalls and clouds. Provisions have been made for a video data recorder and a playback kit which will help avoid operator saturation.

Some of these radar units are operational in Vietnam with good results in certain instances. The major problem in the combat operations is the jungle blockage. Most tactical situations are in areas where the line-of-sight is extremely limited—thus the units seldom operate near their maximum range ability.

Another disadvantage with current radar sets is that a relatively unsophisticated receiver can detect the presence of the radar long before the U.S. unit can spot the target. There is an effort to circumvent this somewhat by developing means of concealing radio frequency emanations from radar.

This last disadvantage is not considered to be a major one by combat standards in Vietnam.

Acoustic devices—There are sound-ranging and other acoustic devices in the development cycle as well as in operational equipment. Microwave and laser technology is being used in two devices for artillery ranging.

The surveying instrument, distance measuring electronic microwave, Model MC-8 (DME), measures distances from 200 to 500,000 meters with accuracy. There is a numerical readout. A lightweight, manned-portable XM23 laser range finder will be used by forward observers. This particular device should increase the first-round hit probability of direct and indirect fire weapons.

Most of the forward area systems can be used as offensive intelligence sources and for the defense of 360-degree perimeters. The security of troop areas in combat zones ranges from the ears and eyes of the soldier to fairly sophisticated devices.

One device, in heavy use in Vietnam, is relatively simple. It is actually only a cut above the old standby of pebbled beer and ration cans. Known as the AN/GSS-9 alarm set, anti-intrusion, the unit is a small, battery-operated box. A thin, almost invisible wire is pulled from the unit and positioned in patterns across the area to be secured.

When tripped, the device sounds an alarm. Numbers of these placed around a perimeter can be effective in alerting the defenders to an enemy—or at least indicate that there is something moving.

Tunnel detection and mapping has the Pentagon searching for answers, concepts, equipment and techniques in every facet of U.S. industry.

U.S. forces now pump smoke into tunnels to spot other exits—and the item involved is a commercial insecticide spray unit.

The manufacturer was suddenly confronted with orders for hundreds of these units—and a second, more powerful version is moving into the inventory.

Detection is only a part of the tunnel problem—although it is the major portion. Once found, these redoubts have to be rendered useless or denied in some way to the enemy.

The amount of conventional explosives required to demolish these networks is normally beyond the load-carrying capability of combat patrols. Some chemicals have been used for tunnel denial for up to six months. Chemicals which can deny their use for periods of several years are in the U.S. inventory but cannot be used due to national policy ruling.

These tunnels are often extremely complex and impossible to detect from the air with present equipment because of the jungle canopy. The effort to come up with portable, lightweight equipment designed to detect such strongholds in combat situations is immense.

But R&D experts also know that the priority level will drop drastically should combat in Vietnam cease for whatever reason. The tunnel problem seems to be unique with this area of Southeast Asia—many of the tunnels were built years ago during the fighting with the French.

Army experts, as well as high-level DOD officials, are confident that there will not be any single solution to any of the detection problems facing the U.S. in Vietnam. The response time is much too short for this.

Longe-range research programs may well apply present and future technology to today's problems and create simple, portable, lightweight equipment—just in time to be modified for a totally different environment and enemy. ■

RIGHT: Soldier uses Army's new infrared target sight, which operates on or off a variety of weapons. BELOW: Laser range-finder operated by forward observers is designed to improve first-round hit probability of artillery.

Searching For Enemy Radar?

Bendix-Pacific has developed a sophisticated airborne radar warning and homing system. Information is available to qualified concerns. Please address inquiries to Bendix-Pacific, North Hollywood, California.

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Advanced plastics materials problems solved by

SOLAR

PROBLEM: Synthesize a new plastics material for damping the high temperature sheet metal structures of gas turbines to reduce vibration, without increasing the gauge of the metal.

SOLAR'S SOLUTION: Working in Solar's Reinforced Plastics Laboratory, engineers found it necessary to synthesize an entirely new tailored plastic in order to meet application requirements of the problem posed above. The result was a synthetic plastic Solar calls Vibrasorb HT 6-4. Not only did this new material reduce the vibration of sheet metal structures without increasing the gauge of the metal, but it also yielded important bonus benefits. These included: excellent high-temperature insulation, reduction of transmitted noise, and protection of metal parts from corrosive and erosive environments.

Turbine exhaust collector and combustion chamber coated with Vibrasorb.

Vibrasorb HT 6-4 is a unique combination of foamed viscoelastic, energy dissipating compounds and refractory reinforcements designed to operate continuously, from sub-zero to 800F in the 10,000 to 30,000 hours range, and intermittently in the 1000F vicinity.

Solar engineers believe that Vibrasorb is the only material available today that will maintain its damping properties above 350F for extended periods. It is applied to prevent failure wherever the input frequency is the same as the equipment's natural frequency. Resonance metals respond to the input energy with motion or vibration. This motion increases, is amplified, as the total input energy is stored. Vibrasorb HT 6-4 controls this condition by converting mechanical energy (causing motion) into heat, which is dissipated.

The high efficiency of Vibrasorb HT 6-4 has been demonstrated through applications to the hot wall structures of Solar turbomachinery and the cryogenic conditions of Solar aerospace products.

Vibrasorb HT 6-4 is made in various heat-stable colors, has an indefinite shelf life and application precautions compare with factory paint spray operations.

PROBLEM: Create new polymeric binding materials, which will provide design engineers with new assembly techniques not possible with existing materials.

SOLAR'S SOLUTION: Research scientists at Solar have developed many specific-purpose adhesives. Among them are two outstanding examples viz. Solabond AD-1 and Solabond AD-1000.

Solabond AD-1 is a modified, formulated polymeric material, originally developed as an air frame type structural adhesive, to withstand high peeling loads. A recent application of this new adhesive is spot-bonding of truck instrument panel stiffeners during the assembly process. These stiffeners were formerly spot welded. Use of adhesive spot-bonding simplified the process – saving time and expense – without degrading the function of the stiffeners. The stiffener is bonded in place by use of a heating tool such as a soldering iron at several spots. Solabond is applied to all the surfaces to be bonded and the adhesive remains soft until the entire assembly passes through the paint drying ovens which set the paint and cure the adhesive at the same time. The spot-bonding occurs in less than 60 seconds at a temperature of around 600F. The cured adhesive is designated to operate in the cryogenic to 250F range.

Testing materials bonded with Solabond.

Solabond AD-1000 is a high temperature polymeric material originally developed as a laminating resin, for hot wall structural uses in the 500-600F range for periods of 20,000 hours and short time 1000F operation. It is characterized by high flexural modulus, and strength. It is supplied as an easily pre-formable precursor stage, which upon cure yields the high performance material described above.

In addition, it can function as a metal to metal adhesive (through proper formulation), as well as a coating, and film forming material.

For more complete information on VIBRASORB HT 6-4 or SOLABOND, write: Solar, Dept. O-165, San Diego, Calif. 92112.

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JATACS To Answer Joint Tactical C&C Requirements

by Walter Andrews

WITHIN TWO MONTHS, the Air Force will forward to Defense Directorate of Research and Engineering (DDR&E) a program for Joint Advanced Tactical Command and Control Systems (JATACS).

It will make specific recommendations for the procurement of subsystems designed to make present-day command and control systems, described by one official as a "can of worms," compatible with JATACS where interfaces exist. It will also make specific recommendations to ensure that future command and control systems are developed with optimum joint tactical operation by the four services in mind. Research and development on JATACS will be funded at $11 million during Fiscal Year 1967.

In the last two weeks, DDR&E also was presented with a tri-service program for setting up a schedule and division of effort toward creation of a tactical communications satellite system to be in service in five years (M/R, Jan. 31, p. 58). Requests for proposals for the first experimental tactical satellite, to be launched early in 1967, will be issued by DOD within the next two months.

Both reports, important as they are to the services and industry for their impact on the shape and design of future systems, only point to the urgency of tactical command and control activity that has of late hit the Pentagon.

Within the last few weeks, the Air Force set up its first operational requirements group for tactical command and control, headed by Col. F. C. Schmidt.

In January, a memo was sent out by the Office of the Secretary of Defense to the effect that all tactical systems to be built in the future would have to satisfy joint military operations. It directed that procedures be set up in the services to see that such a requirement is satisfied.

The reorganization of DDR&E last fall, creating a new deputy director for communications and electronics and a tactical control and surveillance group in its Tactical Warfare Systems Office, indicates DOD's concern in the area.

Reliable communications equipment in the hands of a patrol team is the key to fighting the Viet Cong. New PRC-25 field radio is being used here.

Comsat impact—The advent of tactical communications satellites will have a definite effect on the design of communications equipment. The more power that can be placed in a communications satellite, the smaller ground stations need to be. A great deal, if not all, communication in tactical situations will be by digital data links. Much of the tactical communication that is done today by wire, HF, VHF, and UHF will be shifted to the 7-8 Gc bands.

Such a change would be especially beneficial to the Naval Tactical Data System (NTDS), which relies heavily on HF communications. Use of tactical communications satellites would make a big difference to the Navy. It could eliminate the need for the high-powered HF equipment.

But just when and how extensive these changes will be depends on the pace and results of the tactical satellite program, which also depends heavily on the work being done in other DOD satellite programs.

Slippage of the *Titan III-C* shot in May could set the program back almost a year, according to DOD. In addition to the eight IDSCP (Initial Defense Satellite Communication Program) satellites, the *Titan III-C* will carry piggyback a *Lincoln Experimental Satellite (LES-5).* Expected to be a UHF repeater satellite, *LES-5* could demonstrate the feasibility of satellite communications by means of UHF equipment, of which the services have a substantial inventory.

But important as the TacSatCom program is to the orderly development of tactical command and control, the services and DOD are faced with immediate and more pressing problems:

Sensors—Major attention is focused on updating and replacing field sensors, World War II-vintage radars, direction control centers, and communications equipment. Tri-service efforts are being made toward the development of lightweight radars having a significant increase in reliability. For example, the 300-lb. personnel vehicle locator radar is being reduced in weight to less than 50 lbs. without sacrificing performance, DOD says. The 3,000-lb ground-based air search radar is also being reduced to less than 700 lbs. without sacrificing performance.

Advanced development is continuing for a lightweight, man-portable radar for forward area uses and guerrilla warfare. Development is also continuing for additional airborne surveillance and target-location capabilities.

According to DOD, approximately $9 million is being spent during FY '66 for R&D in this area, and $12 million is programmed for FY '67.

Semi-automatic equipment—Considering the increasing complexity of weapon systems and the insatiable appetite of commanders for information, the trend to semi-automatic command and control systems seems inexorable.

Semi-automatic equipment is being defined for use in new Air Force tactical air control centers. In the last few weeks, requests for proposals on these new operations centers have been sent to industry.

During the past year, DOD has been filling its urgent Vietnam needs in this area with initial buys of off-the-shelf-type items and items requiring only relatively minor engineering development efforts, such as air-control-post radars and operations centers, troposcatter communications systems and mobile communications centers.

DOD is spending about $6 million on tactical air control in FY '66, and will continue its R&D effort in FY '67 at about $3 million, including the contract-definition studies for the new operations centers.

Doctrine—Considerable effort is being expended within the Joint Chiefs of Staff and DDR&E on the writing of doctrine for tactical command and control. Much of it concerns the respective roles being played by the Army and Air Force in the close-air-support situation.

Another problem arises from the introduction of more sophisticated and faster-reacting weapon systems.

In planning future air support syssems, a problem that must be resolved is whether control of artillery or surface-to-surface missiles should be fully mated with air support.

This doctrinal review of tactical air support has been given top priority within DOD.

The review is important not only to DOD in its overall needs, but also to the individual services, since each must design systems that are necessary and unique to its own requirements, and to combat situations in which a particular branch may be operating by itself.

Compatibility—Emphasis in DOD, especially within the last six months, has been on the compatibility of various command and control systems with each other.

Extremely important to this drive is the work being done by the various standards groups in the Joint Chiefs of Staff. What is particularly needed are standards for data rates and displays. The example mentioned in citing this need is the different data rates that exist between the Air Force's 412L system and the Naval Tactical Data System (NTDS).

As standards are written by the JCS groups, they will be incorporated into the design of new systems and subsystems.

Universal language?—The type and degree of compatibility required for the interface between different command and control systems may vary with the particular systems involved.

For this reason, according to the thinking in DOD, it is premature to talk about a universal computer language. One may not be needed.

DOD is reluctant to become "locked-in" to a standard language and computer, since the application of electronic data processing to tactical command and control is just beginning.

But, according to some sources, the Air Force and the Army strongly desire standardized, procedure-oriented computer language for command and control. One of the recommendations of the Kroger report (named for Marlin Kroger, assistant to the president of North American Aviation's Autonetics Div.) was the adoption of JOVIAL as the computer language for tactical command and control.

An interesting part of the Army's requests for proposals sent out last month for its Tactical Operation System (TOS) was the statement that the JOVIAL computer language was "desired."

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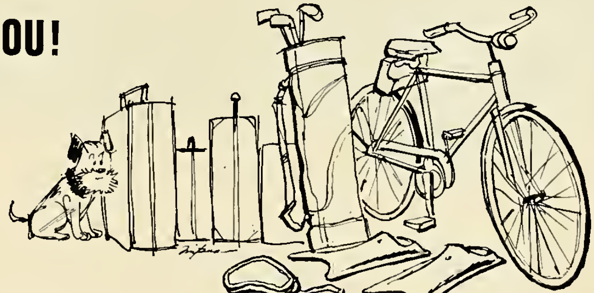

Several hundred engineers and scientists are already setting up for the static firings of the 1st and 2nd stages of Saturn V. General Electric's responsibilities in this king-size program are to support NASA's Mississippi Test Facility, located only 45 miles from New Orleans. A "hot" firing of the second stage of the Saturn V has been scheduled for spring.

This first firing of the test vehicle signifies the beginning of MTF's role in the exploration of space. And it is only a small preview of what's to come. Much more will follow, for years and years. A partial listing of current openings at General Electric's Mississippi Test Support Department:

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The language was not "required" in the RFP, according to some, because it is not known if a sufficient number of efficient JOVIAL compilers are available from a number of companies.

JOVIAL is considered the best interim computer language by the Army. But it is expected that an official decision will have to be made on the language before actual work on the TOS system is begun. Compilers, costing in the neighborhood of $500,000 to $1 million, represent a considerable investment for the services and DOD, it is said.

Some resistance within DOD to the adoption of JOVIAL as a standard language is thought to come from DOD's installations and logistics people, who desire COBOL. The latter, it is said, is desirable from the standpoint of common procurement and the common training of programmers.

The future—The future, i.e., the time frame for which a particular command and control system is being designed, poses to some extent a cumulative problem separate from its components.

In planning a command and control system, a projection must be made of the type of weapon system to be used in the time frame contemplated and the type of data system available to handle these weapons.

It is noted in DOD that it is difficult, if not impossible, to specify within the next four years what type of data systems will be introduced.

As an illustration of the problem, it is said that the computers used in two systems, the ATDS (Airborne Tactical Data System) and the NTDS (Naval Tactical Data System), had their logic worked out for weapon systems and aircraft contemplated at the time of their conception. Insufficient projection and "some bum choices in tactics" have resulted in the reprogramming of some of these fixed-wired machines for operation under present-day conditions.

To varying degrees, DOD has these same problems in the command and control systems in development and being placed in operation.

407L—A prime example of the evolutionary, building-block approach to the design of a command and control system is the Air Force's 407L. Elements of the system, such as the AN/MRC-108 communications unit, are being deployed in Vietnam.

A selection of either Hughes or Westinghouse for development of a 3-D radar for use in the 407L system is expected to be made imminently. Presentations were made to the Air Staff in January.

The development of a lightweight radar is important to the mobility of the system. The tactical radar developed for the 412L system deployed in Europe was not mobile enough. The 412L, originally meant to be mobile, now uses "fixed-site" radar trucks, it is said.

Hughes, along with Litton, has also been selected by the Air Force to perform contract-definition studies of the complete 407L Tactical Air Control system.

Total cost of the 407L system has been estimated at $100-$200 million, depending on how much of the system is implemented.

Airborne Tactical Data System (ATDS)—The air-threat oriented complement of the Navy Tactical Data System (NTDS) carried on the E-2A aircraft is about in the mid-stage of production.

It is estimated that a total of 60 aircraft will be produced, and that the program will be complete in about two years.

The radar used, the APS-96, is primarily an overwater radar, and is complete in its fleet defense function. It is limited in that it cannot move in too close to land because of ground clutter. This ground clutter becomes intolerable somewhere under 100 mi. from shore.

Since last August, the Navy has been flying an improved radar, the APS-111, aboard an E-2A, which shows promise of solving this latter problem.

Naval Tactical Data System (NTDS)—An operational system concerned primarily with fleet air defense, it has been installed in a number of ships.

Under development are fully militarized computer systems, displays and output devices and high-speed data-transmission links for fleet use as an integrated shipboard combat direction system. Further development funding is approximately $3 million for FY '66, and around $4 million for FY '67.

The new *Tartar D* fire-control system, which will uprate the *Tartar* missile and smooth the transition to the standard missile, will also be incorporated as part of NTDS during FY '67.

Marine Tactical Data System (MTDS)—Seven squadrons of the Marine air service will be equipped with MTDS, which will operate as the landward extension of the Naval Tactical Data System. It is defined by DOD as a fully militarized, helicopter-transportable, semi-automatic tactical air command and control system for combat direction of both tactical air and air defense forces in support of amphibious assault operations.

Equipping seven squadrons with MTDS will leave the Corps with three first-line squadrons and several more in reserve with "manual" command and control systems. All squadrons will not be equipped with the system, since DOD wants to see how the system will per-

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form, the rationale being that it would not cost significantly more to wait another year.

Main problem in the system has been the weight and reliability of the computer. Operational evaluation of the system was begun in January, and will be completed by the end of August.

Additionally, the Navy Department and the Marine Corps have been requested to submit a plan for modernization of those Marine Corps manual systems not planned for replacement with MTDS to make them compatible.

Development funding for MTDS is about $3 million for FY '66 and will be $2 million for FY '67.

A-New—Perhaps the most important command and control system in the years to come, considering the potential Chinese threat of submarine-launched ballistic missiles, will be A-New, the Navy's integrated anti-submarine warfare avionics system.

Since the first of the year, an engineering prototype of the system, a Mod-3, has been undergoing test and evaluation at the Naval Test Center, Patuxent River, Md., in a P-3 (Lockheed Electra) aircraft. A Mod-1 version of the system was previously used to illustrate the value of digital data processing in an ASW system. Completed last December, tests of the Mod-1 version, which was not a completely integrated system, proved very conclusively that significant improvements in ASW effectiveness were obtained by the use of digital data processing.

It is estimated now that A-New will about triple the amount of data than can be handled from acoustic sensors. It will greatly relieve the pressure on ASW subsystems. The Mod-2 version of A-New was strictly a laboratory mock-up of the system.

Complete test and operational evaluation of the presently contemplated A-New system, which will be in a land-based aircraft, is slated to be completed by mid-1967. Following this phase, initial production prototypes will be made for reliability and qualification testing. The system is expected to be operational by 1969.

Requests for proposals for the data-processing equipment to be used in the system are expected to be issued by the Navy imminently.

Work has recently begun on another A-New system, one that will be incorporated in carrier-based rather than land-based aircraft. It is known as the VS phase, as opposed to the VP phase for the land-based aircraft.

The VS will not perform a different function from that of the VP, but it will be carrier-based. It will also have a three- or four-man crew rather then a 12-man crew.

Planned for the fleet for the early 1970's the VS carrier system will involve a new airframe around a new A-New system. Reduction in size will be accomplished by liberal use of microelectronics, elimination of crew members by automated equipment, and time-sharing of electronic functions, i.e. use of multi-function electronic equipment.

The first flying engineering prototype of the VS system is not expected until sometime in 1968.

Both the VS and VP versions of A-New will use the same type of radar, with the former being in a somewhat smaller package.

Automatic Data System for the Army in the Field (ADSAF)—Conceived during the last year, this system consists of three subsystems, a new Tactical Fire Direction system (TAC FIRE), a Tactical Operations System (TOS) for providing current, accurate, information and intelligence for commanders, and a Combat Service Support System (CSSS) for providing logistic support.

A qualified material requirement (QMR) was approved by the Army in January for the TAC FIRE system, and has been sent to some 300 companies that have expressed an interest in the program.

Requests for proposals on TOS, which is mainly a software design effort, have been recently issued, and a bidders' conference was held earlier this month. Some expect the RFP's on the TAC FIRE portion of ADSAF to be sent to industry before the end of 1966.

AWACS—The Air Force's Airborne Warning and Control System (AWACS) has recently been reoriented, and a five-year research and development program has been initiated beginning with this year. The program will consist of study phases and operational analysis for the first year and a half.

The Air Force is expected to move into the contract definition phase for the system late in 1967 (M/R, Jan. 10, p. 16).

The Air Force still considers the program a two-pronged effort, one being development of AWACS as an operational system, the other a long-term radar technology project expected to continue for more than 10 years. But DOD sees the go-ahead on AWACS as dependent on the development of overland radar technology.

Westinghouse, Raytheon and Hughes are performing development studies in the high-, medium- and low-pulse repetition frequencies, respectively. Hazeltine Corp. is also working on a Doppler side suppressor radar and the General Electric effort on the APS-111 radar is also considered as having relevance in this area. ■

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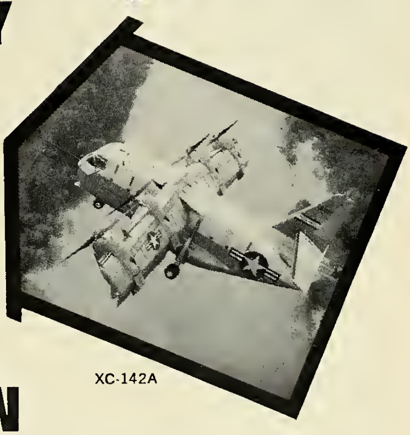

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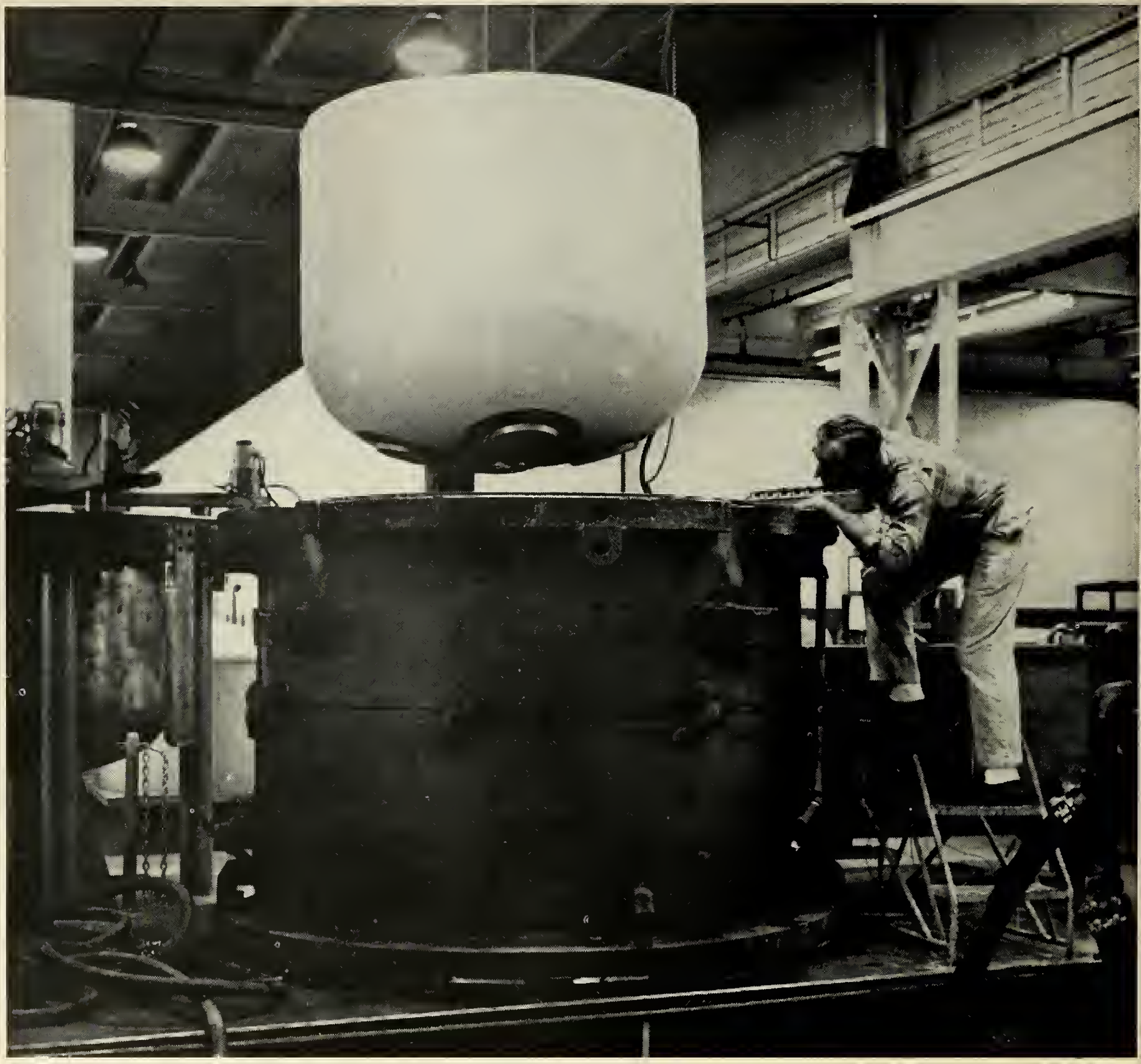

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Industry Acts to Meet Novel Problems

A company-by-company examination of some of the efforts being made to satisfy the unprecedented limited-war needs of military

by Williard E. Wilks

A SAMPLING OF U.S. industry by MISSILES AND ROCKETS indicates that a wide variety of programs is being undertaken by firms attempting to expand their traditional talents into some of the more perplexing problems of tactical—and at times unconventional—warfare.

Canoga—An example of how "Space-Age technology" can be applied to the tactical warfare problem is an electronic device for opening cargo parachutes developed on company funds by Canoga Electronics, Canoga Park, Calif. The firm recently delivered a number of pre-production units to the Air Force at Eglin AFB, Fla., for flight tests.

The device, known as a "chute popper," consists of two main pieces—the airborne unit, which is about half the size of a cigarette carton and is placed in the parachute reefing, and the ground unit, which can be hung on an infantryman's ammunition belt. Its use makes it possible to drop cargo in a method similar to a bombing run.

By visually observing the package, the ground controller can decide to open the parachute at 300-500 ft. if it is going to fall in the target area, or to let the package impact if it is headed for enemy territory. By permitting the package to free-fall to a low altitude, wind drift of the parachute is controlled. The ground unit, equipped with a push button, supplies modulation signals through existing back-pack communications equipment. The command signal fires a squib in the airborne unit.

The Air Force also believes the device will permit cargo aircraft to remain high enough to minimize sniper fire.

Ryan—A different approach to the same problem has been taken by Ryan Aeronautical Co. with its expandable flex-wing precision drop glider (see page 96). While the glider is being produced on Army contract, the company devoted some of its own effort to the development in the early stages and now is engaged in further effort to adapt the glider to replace the parachute for airborne troops.

RCA—The Defense Electronic Products group of Radio Corporation of America, Moorestown, N.J., reports a great deal of company-funded work on

Hughes-built manpack radio is now being produced for the Army. The solid-state SSB radio operates in the 2-12 Mc range, weighs 29 lbs., can operate with either dry or wet cell batteries, and reportedly provides access to 10,000 channels.

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Sewn cylinder rod bellows boot

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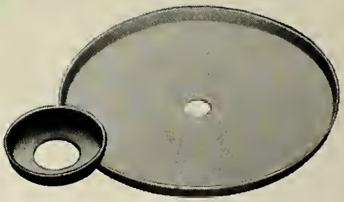
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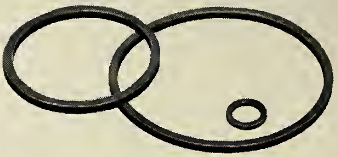
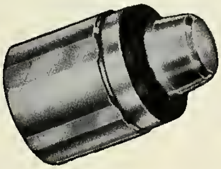
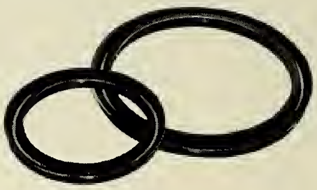
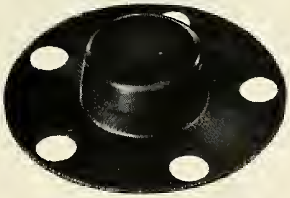

Sirvon* sealing rings


Valve seal

Sirvene** piston cups


Sirvene** block Vees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Dust generated by parched ground throughout central and northern South Vietnam has caused considerable maintenance and health problems for GI's. Methods of ground stabilization and dust control are sought from industry. (M/R photo)

techniques which could be applied to tactical warfare.

Sometime this spring, RCA expects to announce the availability of two new systems which have direct applicability to the Vietnam operation, and which will be proprietary company-funded developments that company spokesmen say will leap-frog all known equipment in capability.

One of these is a portable air-surveillance radar which can be carried into combat stations by groups at the squad level and erected within 30 mins. This is said to be so simple in construction and so inexpensive to produce that it will be practical for "throw away" missions in which it will be cheaper to destroy the instrument than to transport it from place to place.

The other is a hand-held surveillance and fire control radar for individual ground troops which reportedly will outperform any other known device by an order of magnitude, yet weighs less than the soldier's rifle. Four prototypes are now being bench-tested, and are slated for field-testing in a month or two.

Avco—Avco Corp. also reports a great deal of activity in limited-warfare applications. The Research and Advanced Development Div., Wilmington, Mass., is investigating development of ceramic armor. One application is for a lightweight personnel armor protection. A possible further application might be on sections of helicopters and reconnaissance aircraft.

Avco also has proposed a concept for a small tent made of aluminum. This could be carried as pack equipment and would be set up in the field by air pressure, retaining its structural integrity after pressure is released.

In the area of protective coatings, the Avco division has made preliminary investigations which could result in development of materials for protection against erosive damage of rain and hail. One such application could be a protective coating applied to helicopter blades.

The firm is also examining alkali metals such as sodium, potassium, lithium, cesium and rubidium for their light-producing properties when electrical discharges are operated through them. Applications could be found in reconnaissance, surveillance, and fire-control operations. In addition, alkali vapor lamps are being studied with company funding.

Although Avco/RAD has been involved in development of advanced systems for strategic warfare for 10 years, R&D in missile systems technology specifically intended for limited warfare is in its beginning stages.

Under current study are such requirements as aircraft and tactical missile penetration aids, improved high-muzzle-velocity gun shells, development of a new mine concept, and air-launched tactical missile fuzing systems.

In the ordnance area, Avco/RAD and Avco Ordnance Division have started a program of close technical interchange involving the application of advanced re-entry technologies and engineering to new ordnance items.

Avco's Ordnance Division at Richmond, Ind., has spent several years working on its Avroc series of weapons with a minimum of help from Government agencies (M/R, Nov. 1, p. 14). All of these weapons are extremely lightweight with low recoil and can be manufactured with conventional techniques and materials. Ammunition is rocket-boosted and spin-stabilized, and has produced accuracies not previously obtained with projectiles of this type.

Avco's Lycoming Division, which produces the T53 and T55 gas-turbine engines that are seeing extensive duty in Vietnam, is engaged in two major categories of R&D. One is advanced development work in connection with the two existing gas turbine families to provide higher-rated versions of both models. The other, development of a radically new gas turbine known as ATAC for tanks and other vehicular applications, is Army-funded.

Arma—The Arma Division of American Bosch Arma Corp., Garden City, N.Y., has several programs under way with both company and military support. These include the Land Navigation System, which reportedly permits pinpoint navigation of tanks, trucks, personnel carriers and amphibian vehicles in completely unfamiliar territory under all weather conditions and in total darkness. The LNS operates on the principle of automatic dead reckoning, utilizing a gyrocompass to determine direction and the vehicle's odometer cable for information on distance.

The division also has developed an inertial platform test set which it believes is the first that operates reliably on aircraft carriers. Another program applicable to tactical warfare is a series of suitcase-type equipment for use right on the flight line to check out such aircraft equipment as radar and guidance.

GE—In the weapons area, General Electric Co. currently is testing a 5.56-mm Minigun which is a smaller version of the 6,000-shot-per-minute 20-mm Vulcan gun and the 7.62-mm Minigun. The 5.56 is capable of 11,400 shots per minute. This effort is under way at the Missile and Armament Division, Burlington, Vt.

Already developed is a low-cost guidance system which could be used in short-range tactical missiles. It could be produced in quantity for $10,000 to $20,000. The three-gimbal system with its electronics, including a simple analog computer, is 11 in. in diameter, weighs 19½ lbs. and has a g-load capability of 25 g's.

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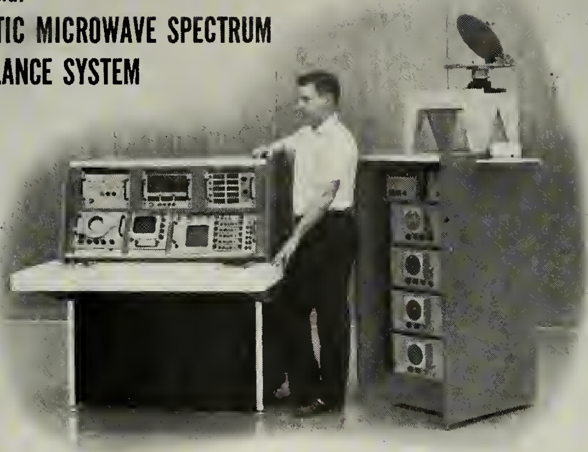

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- Digital tuning and direct digital readout delivers automatic data for transmission and teletype reproduction.
- The ability of the system to measure frequency to an accuracy of .01 percent is the result of a solid-state local oscillator development unique at W-J.
- The system is of solid-state design throughout, except for TWT's and CRT's.
- A core memory unit provides a "lock out" and recall capability.
- The modular design provides for ease of system expansion to cover the 18 to 40 GHz range as well as frequency bands lower than 1 GHz.
- Each module is fully self-contained with its own power supply (diplexers, local oscillator synthesizer, spectrum display, DF display, demodulator, digital tuner, receiver control, frequency memory, IF pan display, analysis indicator and so forth), resulting in a perfectly synchronized system.
- Supplementary equipment is available to suit any application.

The team that delivered the WJ-1007 as promised can be engaged to any similar systems program calling for refined skills and engineering ingenuity.

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UTC—At United Technology Center, where funded work is primarily in big solids, scientists and engineers are engaged in a variety of company-funded research and hardware development which show promise of tactical warfare applications.

One of the more promising UTC developments is a new solid fuel binder. It is compatible with an advanced and highly reactive oxidizer and provides improved propellant stability at extremely high temperatures, such as those encountered by air-launched missiles.

UTC studies indicated that high-performance hybrid rockets offer important advantages for extremely fast, low-flying tactical missiles. Cost and safety factors are other considerations which seem to favor hybrids for a number of tactical assignments, according to company spokesmen.

Propulsion studies also are under way at UTC on storable, pre-packaged liquid systems and stop-start solid motors. Still another area of research and hardware development is in the use of a hybrid rocket power source for brief, but huge, bursts of electrical energy through magnetohydrodynamics. Such a system could be designed for battlefield use to power advanced weapon systems.

A recent program which evolved from UTC's broad experience in chemical propellant handling and mixing resulted in design and fabrication of a portable unit for mixing and filling napalm containers in forward battle areas.

Hercules—Hercules Powder Co., Wilmington, Del., is funding R&D in a number of general areas which may be useful in meeting the needs of tactical warfare.

Significant work has been centered on devising structural components that will take advantage of the unique properties of continuous glass filaments. Extremely lightweight pressure bottles that are capable of handling liquid or gases at very high pressures have been designed. In addition, lightweight, weather-resistant shelters have been fabricated to show that they would permit easy transportation by helicopters and quick movement from site to site. Filament-wound submarine-escape capsules also have been designed and tested.

Slurry explosives are fairly insensitive, thereby easing logistic problems, and possess excellent high-detonation velocity and brisance. Hercules is seeking tactical applications for them. R&D of new and better gun propellants for all calibers is a continuing effort; these propellants could be used at extreme temperature limits, affording high specific energy, controllable rate, and low cost.

Hercules studies in the general area

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of tactical rockets are concerned with propellant characteristics of ultra-high burning rates, low radar attenuation exhaust, high physical properties over a wide temperature range, low-cost processing, high energy, and reproducible ignition.

Martin—Martin Co. reports that a significant portion of its company-funded research is aimed at tactical weapon systems. The firm is engaged in such areas as guidance and control (area correlation trackers, laser-guidance inertial reference systems); laser applications (target illuminators, seekers, radar, comunications); armament research; fluidics (guidance, fuzing and control); information sciences (information compression, data processing); millimeter wave technology (communications, propagation, radiometry); and materials (ablative, protective coatings, ceramics, basic research).

At its Orlando Division, Martin maintains a large force in tactical systems research, development, production, testing and logistics. At the Baltimore division, where tactical work centers on manned flight systems, more than a third of the division's in-house R&D is devoted to this area.

Martin reports that it is in the area of aircraft modification and aircraft component production that it sees the most direct effects of stepped-up tactical procurement. The aircraft business at the Baltimore plant has grown from sales of $19 million in 1964 to $32 million last year.

NAA—North American Aviation, already heavily involved with hardware in Vietnam, has a special group set up at its Autonetics Division to bear on the tactical mission. This effort is partially funded by the company. Investigators are considering anti-SAM missile configurations and several personnel detection devices.

NAA also is studying jet configurations of low-cost, high-production-rate, close-support fighters and a flex-wing precision-drop cargo delivery system similar to the Ryan program with the Army.

GD—At General Dynamics' Pomona Division, the *Redeye* program, originally a company-funded effort, is just moving into production.

A recent in-house development at Pomona Division is a new field communication system. Elsewhere in GD, Electronics Division, San Diego, Calif., has developed with in-house funds a terrain-following radar. Currently being redesigned for a production version, the radar can fit quickly into the low-level strike picture in any limited-warfare application, according to the firm.

Northrop—At Northrop, a compact "Suitcase Navigator" has been developed which has possibilities for use on tactical aircraft. The self-contained system weighs less than 60 lbs.

Significant work is conducted at Northrop's Nortonics Division, where research and testing is directed toward development of entirely new weapons, including multi-purpose, small tactical missile warheads for use against both aircraft and ground targets.

Lear-Siegler—At Lear-Siegler, a new LORAN navigational system uses an on-board converter-computer to determine location from LORAN information, with either a map or a digital readout.

Garrett—Garrett Corp., active in research to improve its T-76 turboprop engine, also has developed a new field hospital known as MUST (Medical Unit Self-contained Transportable). The 400-bed portable unit came out of Garrett work in inflatables.

Aerojet—Aerojet-General is conducting research toward improved ordnance items and improved lightweight armor for both personnel and vehicles.

Lockheed—Lockheed Aircraft has concentrated its limited-warfare effort by designating a technical representative in each major operating division to coordinate its interest and activities with cognizant field offices and corporate headquarters. Major effort at the Burbank complex is in the rotary-wing field. Although all of this work now has contract support, the company has poured millions of its own funds into the effort. Most of the company-funded support is directed at application of the rigid-rotor concept to compound rotary wing machines.

TRW—TRW Systems reports effort over a broad area. In the tactical missile field, work includes terminal guidance and in-flight alignment techniques for air-launched missiles ranging from *SRAM*-type weapons to smaller anti-radiation missiles. This encompasses target identification and acquisition with equipment mounted in the aircraft.

Other TRW Systems work includes noise-jammer electronic countermeasure systems, electronic intelligence systems and components, very-high-intensity ablative flashing lamps for photo-reconnaissance, ground signaling and homing, prototypes of a wide-band laser recorder/reproducer, development of strapped-down guidance systems for aircraft or larger tactical missiles, development and testing of materials for application to perimeter defense, bioelectrochemicals for use in fuel cells, bacteria detectors and field life-support systems.

Westinghouse—Aerospace Electrical Div. of Westinghouse has recently brought out the first of a new family of forward-area tactical engine-generator power systems. The systems have been demonstrated at the Army's Ft. Belvoir, Va., Engineer R&D Laboratories.

Initial system is a 60-kw, 400-cps unit which Westinghouse says provides high-quality electric power at a lower mission weight than presently available equipments. The system weighs 1,100 lbs., is about 3 ft. wide, 3 ft. high, and 4 ft. long.

LTV—Ling-Temco-Vought's spending for R&D is now running between $12-15 million annually, say company spokesmen, and much of this is devoted to equipment for tactical warfare—an area of specialization which has turned out well for the Texas-based firm. The firm holds prime contracts for the Navy A-7A attack aircraft, also to be bought by the Air Force; for the Army's *Lance* missile, for which heavy production runs are forecast (M/R, Mar. 14, p. 9), and for the XM-561, six-wheeled support vehicle now in test.

Much of LTV's effort is directed at the V/STOL field, where considerable long-range pay-off is anticipated.

Sikorsky—With more than 100 helicopters already in service in Vietnam, Sikorsky Aircraft is pumping new R&D money into a variety of designs including new heavy-lift helicopters, compounds, stowed-rotor configurations, tilt-wing systems and jet-thrusting craft.

Specific studies and designs have been prepared for two new craft: the Navy's light anti-submarine attack helicopter, and the UTT, a new DOD transport chopper.

Boeing—Boeing's Vertol Division, Morton, Pa., is also especially active in the tactical field with helicopters and studies of V/STOL aircraft. Vertol has scheduled construction of a new $5-million engineering laboratory building near Ridley Township in suburban Philadelphia, together with what it describes as the world's most advanced wind tunnel for helicopter and V/STOL research. The Vertol engineering laboratories will include transmission, propulsion and fuel-system sections for advanced product development programs. The laboratories will house $6 million of new equipment.

Cubic—Cubic Corp. has parlayed its long-term experience in geodetic survey into development of a new Long-Range Survey System (LRSS) for the Army to improve artillery-fire first-round accuracy. The system is now in contractor test at Yuma, Ariz., and could be in service in Vietnam by summer.

The system, which reportedly is lighter and has a longer range (275 km) than existing equipment, employs automatic data processing to provide an all-weather and all-terrain capability for rapid mapping and fire control.

The LRSS includes a master station, man-portable base stations, up to 50 man-portable positioning equipments, and an airborne relay unit for extending communications beyond line of sight. ■

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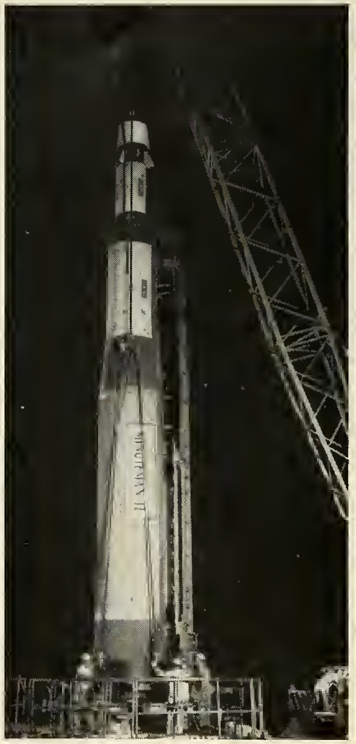

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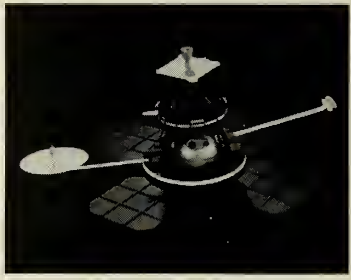

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SECTION III

THE NEW MANAGEMENT AND THE NEW BUDGET

DOD, Services Gear To Manage War

Pentagon effort managed through Project PROVOST, JRATA and ARPA's Project Agile; military establishing quick-reaction procurement methods

by Lawrence J. Curran and Heather M. David

THE WAR IN VIETNAM has begun to flesh out the skeletal limited warfare management structure first established in the Department of Defense and the military services by the Kennedy Administration.

Some of the earlier organizations that helped in the Kennedy days to reorient the U.S. military establishment from its posture of massive retaliation are proving their mettle as troubleshooters in solving the peculiar research and development problems coming out of Southeast Asia.

They include the Advanced Research Projects Agency's Project Agile, the Army's Limited War Laboratory, and the Air Force's Deputy for Limited War and Special Air Warfare Center. These organizations date back to 1961-62, and their experience has been invaluable to similar units, staff offices and *ad hoc* teams that have sprung up as the result of the vastly increased U.S. commitment in South Vietnam.

In addition to ARPA's Project Agile, the newer DOD-level activities include Project PROVOST (Priority Research and Development Objectives for Vietnam Operations Support), the Joint Research and Test Activity in Saigon (JRATA), and a Southeast Asia programming team in the Office of the Secretary of Defense.

A new group has also been set up in DDR&E to reflect the new emphasis on testing made necessary by the Vietnam war. Headed by Rear Adm. Vincent de Poix, the Systems Test Evaluation Group will monitor the test activities of all the services, overseeing the actions of such installations as the Naval Ordnance Test Station and the Limited War Lab.

The purpose, officials indicate, will be to ensure that new tactical systems and materials about to be deployed by any of the services are thoroughly checked out before being sent to the field.

Each of the services has established systems for speeding fulfillment of requests for new or modified hardware originating in Vietnam. Quick reaction has been the first precept followed in setting up machinery to meet these requests.

Speeding the message—A streamlined way of operating has accompanied the establishment of these teams. It entails extensive reliance on electrical communication for authority to proceed with procurement or development of requested hardware.

Dr. Finn J. Larsen, Deputy Director of Defense Research and Engineering, effectively expressed the Pentagon philosophy in a recent address to the Electronic Industries Association. He said that a telegram from the headquarters of Army Gen. William C. Westmoreland, top U.S. military commander in Vietnam (formally, commander of the U.S. Military Assistance Command, Vietnam [MAC/V]), is now tantamount to a requirement, and is expedited accordingly.

Probably the latest Pentagon move to sharpen the reporting of information on Vietnam came in February, when Defense Secretary Robert S. McNamara approved establishment of the Southeast Asia Programs Division in the office of the Assistant Secretary of Defense (Systems Analysis.)

This *ad hoc* body is charged with knowing "everything there is to know" about prosecution of the war in Vietnam, according to Dr. Victor K. Heyman, head of the team, which ultimately will consist of nine professionals and four clerical assistants.

"If McNamara asks us a question about some aspect of the war in the morning, we want to have an answer for him that same afternoon," Heyman says. The question might be quite complex—for instance, how will assignment of another Army battalion to Vietnam affect consumption of 105-mm artillery ordnance in the next six months? Or, what impact will offloading of that unit have on harbor facilities in Saigon?

Heyman's team will rely greatly on computer assists to come up with answers for these questions, but the team's principal tool will be a simple planned-vs.-actual table, revised each month, to project consumption levels for everything from aircraft to rifle ammunition for a two-year period.

The Southeast Asia Programs Div. represents the first focal point for reporting information on the war in Vietnam at the OSD level.

Project PROVOST

DOD is asking $76 million in the Fiscal Year 1967 budget for top-priority research and development items for Vietnam identified under Project PROVOST.

PROVOST, which appears for the first time in the new budget and supplemental bill, is an effort by the Directorate of Defense Research and Engineering to meet the critical need for new kinds of equipment, for speedup of new equipment coming down the line, and for quick fixes to equipment in the field.

Projects selected for PROVOST have top priority in the R&D field at the present time. Selection of these projects is handled by a top-level steering committee headed by Dr. Thomas Cheatham, director of tactical warfare in DDR&E, with representatives from the services at the flag-officer level, along with the director or deputy director of ARPA. The project is coordinated with the services' assistant secretaries for R&D.

The PROVOST shopping list is defined as those projects of critical need in the Southeast Asian effort that can be accomplished in 18 months or less. All items requested by Gen. Westmoreland are automatically put on the list, Cheatham told Missiles and Rockets.

What it does—The biggest benefit a project receives through its elevation to PROVOST status is financial. Funds for the project are available to Cheatham from three sources: The DOD emergency fund, supplemental appropriations, and adjustments in the budget.

Access to these sources of support

Brig. Gen. H. B. Kucheman, Jr., Air Force's recently named deputy for limited war in AFSC's Aeronautical Systems Div.

Dr. Thomas Cheatham heads top-level DOD committee charged with selecting programs that warrant Project PROVOST status.

permit a quick reaction time within DDR&E on PROVOST problems. A rule in Cheatham's office is that any work connected with PROVOST must be handled by his staff within 24 hours, and no man goes home with a PROVOST item in his basket. Timetable for the entire handling by DDR&E is 48 hours maximum.

Promise of such action is very attractive to the services, which have brought up many more candidates for PROVOST status than have been chosen. At two different screenings by the steering committee, a total of about 600 items were brought up by the services and ARPA, and about 75 were actually selected each time, Cheatham said.

About $200 million thus far has been identified with PROVOST projects. In the supplemental request, almost the entire $152-million RDT&E budget is PROVOST or PROVOST-related—$55 million of this being for about 81 programs that are "pure PROVOST."

Examples—PROVOST may not necessarily bring to the field what would seem to be the latest in warfare. For instance, a major project has been modifying the F-4 aircraft to install cannons in its nose.

This was undertaken to meet the criticisms of fighter pilots such as those who recently encountered but were unable to shoot down two MIG fighter planes. They claimed that missiles were ineffective in that particular situation, but that with guns they would have been equipped to down the enemy aircraft.

Modification of the A-7A aircraft to make it acceptable to the Air Force is another example. In this case, PROVOST was brought in to step up the pace of providing the planes.

Improvements of weapons systems also are good candidates for the program, Cheatham points out, since these generally can be made quickly. Improvements to the *Shrike* have fallen under this category.

Other, more general items that have appeared on the list include night operations and night-vision devices; target intelligence and marking; communications; medical advances; tunnel and personnel detectors; improved munitions and weapons delivery; protection of ground troops, and special and/or improved techniques or weapons.

Some of these have demonstrated unusual ingenuity, such as the application of a Sears Roebuck orchard blower to fill tunnels with non-lethal gaseous agents.

Contracting—Procurement and contracting is handled through the usual service channels, and, when quick reaction is needed, through ARPA. To save time, there are no contract-definition stages. Contractor response has been excellent, Cheatham said, and some items have been delivered before they were paid for.

Cheatham's office, while not acting as a contracting monitor, does check on PROVOST project testing.

In addition, the office has augmented support of the services' test and evaluation activities, such as the Army's Limited War Lab, the Naval Ordnance Test Station, China Lake, Calif., and Air Armaments Laboratory at Eglin AFB, Fla., allowing additional personnel and more funds.

Feedback on the operation in the field comes from ARPA, JRATA, and technical teams from DDR&E that visit Vietnam regularly. In addition, two DDR&E representatives are stationed with MAC/V—a number which probably will be augmented, Cheatham said.

JRATA

The Joint Research and Test Activity, which came into being in April, 1964, is one agency that may handle testing in the field of PROVOST-developed items as well as those generated by the services themselves.

Now operating at a strength of about 150, including support personnel, the JRATA organization incorporates the ARPA Research and Development Field Unit, Vietnam (RDFU-V), the Army Concept Team in Vietnam (ACTIV), the Air Force Test Unit, Vietnam (AFTU-V) and the Navy Research and Development Unit, Vietnam (NRDU-V).

JRATA is directly responsible to MAC/V, although the individual services and ARPA exercise administrative and logistic support of their own units.

Director is Army Brig. Gen. John K Boles.

JRATA has the immediate task of acting as a sounding board for the R&D aimed at Vietnam requirements being carried on in the U.S. However, top JRATA officials are quite clear as to the limitations involved.

As one official put it, "We don't test out here, we use." Equipment that goes to JRATA must be proved out as completely as possible in the U.S. As the official said, "If you give me something as a substitute for my rifle, it had better be as good as my rifle. My life is at stake."

Responsibilities—JRATA definitely does not provide services for controlled testing, or simple environmental testing. These can be carried out under Vietnam-like conditions in areas such as Panama or Thailand, which have similar jungle and terrain.

JRATA handles on-the-spot problems requiring R&D attention unique to the combat situation or to the Vietnamese environment. The unit has operational control over all research and test activities within the U.S.

In Vietnam, JRATA provides assistance to MAC/V and to commanders in the field on the status of projects in progress in the U.S., and advises them on the state of the art as they establish requirements for new items.

It also assists the R&D community in the U.S. by transmitting environmental information from Vietnam. Some service personnel are rotated to keep this information flow available to contractors in the States.

While JRATA does not procure directly, it may make recommendations through normal service channels that have a bearing on the selection of particular items.

Other JRATA responsibilities include the study of items in inventory to determine applicability for use by the Vietnamese forces themselves. For instance, a radar unit was found to work well in the field, but maintenance problems put it beyond the capability of the Vietnamese.

JRATA also is involved in optimizing the organization of field units in Vietnam. For instance, a study might involve settling the question of whether a tank company should have the traditional number of tanks, less or more for the peculiarities of the Vietnam situation.

AGILE

ARPA's effort in Vietnam is wholly centered in Project Agile, which has been under way since 1961 and also has units in such areas as Thailand, Panama, and Beirut, Lebanon, to study needs of remote-area conflict.

Agile is physically located at the Combat Development Test Center of the Vietnamese government in Saigon, which also is under the coordinating direction of JRATA.

Requirements for Agile are generated in several ways in Vietnam. Requests may come from MAC/V to JRATA headquarters. ARPA in Vietnam also keeps in contact with developments in the field, and makes its own identification of things that need to be done.

In addition, ARPA headquarters in Washington keeps track through DDR&E contacts and plans its own strategy on R&D needs for Vietnam. DDR&E itself may ask ARPA to handle special tasks.

Out of these inputs, a running list of things that need to be done is periodically reviewed by ARPA directorate. When permission is needed to carry out a study in Vietnam, the request goes from the head of JRATA to MAC/V to Commander in Chief, Pacific, (CINCPAC), and through the embassy in Saigon.

Assignments—Agile has specialized in the past year in software tasks such as analysis of mobility, vehicle tradeoffs and behavioral science. In the latter area, a recent example is the interviewing of refugees to support the Chou Hoi (Open Arms) program for recruiting Viet Cong to the Vietnamese side.

Studies for the military involve quick fixes—although this kind of activity has decreased as the services build their own quick-fix program capabilities. The emphasis now is definitely on the longer-range aspects of counterinsurgency.

Some 120 tasks have been on the books for Agile during the past year. Some of them may be handled on a single contract; others may involve work by only one man for a limited period of time.

ARPA continues to contract through the services in its regular manner, employing its power to use funds in OSD only in special instances. As in previous years, any of the various services may act as agent for ARPA, and work may be contracted to the specially qualified service laboratories such as the Army Limited War Lab or the Marine Corps Landing Fleet Development Center at Quantico, Va.

Another responsibility of the Agile group is in the official technical interface with the Vietnam CDTC. The purpose is to build up Vietnamese capability to perform R&D, both in order to enable it to do its own work and to raise the country's general technical level.

AIR FORCE

The Air Force recently established three principal instruments to assist in meeting the operational requirements of limited war: The Southeast Asia Operational Requirements procedure (SEAOR), an Air Force Systems Command (AFSC) liaison office within its 2nd Air Division in Vietnam, and Project 1559.

The SEAOR procedure and the Systems Command liaison office (Detachment 6) at Tan Son Nhut AFB, Saigon, are particularly geared to the needs of the 2nd Air Division in prosecuting the war in Vietnam. A SEAOR may request completely new equipment requiring considerable development, large-quantity procurement and competitive bidding.

Project 1559 is essentially an AFSC vehicle to provide funds to buy, test and try small quantities of hardware prototypes that appear attractive in meeting a limited-war need. The hardware must be available within six months before Project 1559 funds will be committed to its procurement.

These three recent moves enhance the capability of the Air Force's Deputy for Limited War, an office established in February, 1962, at AFSC's Aeronautical Systems Div., Wright-Patterson AFB, Ohio. This is the Air Force's "lead division" for overall planning for limited war and special air warfare. The urgency of the task assigned this of-

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fice was underscored last December when for the first time a general officer was named Deputy for Limited War. He is Brig. Gen. Henry B. Kucheman, Jr.

SEAOR procedure—The SEAOR system grew out of a Pentagon meeting last June aimed at determining ways to better support the 2nd Air Division. The same meeting resulted in establishment of AFSC's Detachment 6 at Tan Son Nhut.

Only the 2nd Air Division may initiate a SEAOR. Not even U.S. Air Force, Pacific (PACAF), has this authority. The division identifies the need by TWX message to PACAF and simultaneously provides the same statement of need to Air Force headquarters, to AFSC, the Tactical Air Command (TAC), and the Air Force Logistics Command (AFLC).

PACAF immediately reviews the proposed requirements (qualitative operational requirement [QOR] or Class V modification) and transmits tentative approval or disapproval by electrical communication to all who received the SEAOR. QOR's usually request development of new equipment. A Class V modification applies to existing equipment.

If PACAF sanctions the SEAOR, the deputy for limited war at ASD and the appropriate agency within TAC simultaneously prepare best preliminary estimates (BPE) of a techical solution to the problem. BPE's are sent, again by electrical means, to Air Force headquarters. If headquarters agrees with the proposed technical fix, "money will be put on it," as one AFSC source says.

Funding may come from AFLC if the solution requires modification of existing equipment. Air Force headquarters will fund the SEAOR if reprogramming is required. The money may be drawn from Project 1559 if the proposed hardware "fix" or procurement is available within six months.

The BPE generated may identify contractors known to have the quick-response capability a SEAOR requires. Often the BPE identifies the contractor thought to be in the best position to perform the work requested.

Some 37 SEAOR's have been generated by the 2nd Air Division's operational requirements office. The unit consists of five officers and one enlisted man at Tan Son Nhut. Project officers are assigned to four areas: communications, avionics and munitions, reconnaissance, and fighters.

In addition to the 37 SEAOR's already processed, 30 other projects currently are being studied as possible SEAOR's by the 2nd Air Division requirements office in Saigon.

Examples of insufficiencies that have been identified by SEAOR's and for which solutions are on the way include two for rescue of downed pilots.

A strobe light used by the downed flier to signal rescue crews at night was easily detectable by forces attempting to capture him. The light was capped to make its winking signal more directional, but the cap was made of red plastic, causing rescuers to think they were under fire when they saw it. They often returned the "fire"—a logical reaction but one that did little for the morale of the downed pilot.

A SEAOR was initiated to develop an infrared light for use in survival packs and equipment to detect it aboard the search aircraft.

The Office of the Deputy for Limited War is also studying "treescape" devices in use by the U.S. Army and the Australian Air Force to enable pilots who have parachuted into trees to get free. The device under study is simply a 150-ft.-long nylon cord equipped with rubber grippers so that the user can control his rate of descent.

AFSC liaison office—Detachment 6 at Tan Son Nhut serves, according to one spokesman, "to give AFSC commander Gen. Bernard Schriever a quick-reaction capability in Southeast Asia."

It consists of two officers whose task it is to keep 2nd Air Division planners abreast of R&D programs progressing in AFSC. The tours are short—90 to 120 days of temporary duty—so that the office is always staffed with personnel fresh from Air Force laboratories who know of the most advanced technology that might conceivably assist the 2nd Air Division in accomplishing its mission.

Their expertise is of considerable value in formulation of SEAOR's, and it is this program that gets most of their attention.

In addition to this constant on-site liaison, technical teams from AFSC are available to the 2nd Air Division to trouble-shoot specific problems that arise. At least two such teams have already visited Tan Son Nhut—one staffed by communications specialists and another sent to offer solutions to certain survival gear problems.

Project 1559—This effort, initiated in Fiscal Year 1965, provides a funding vehicle for non-conventional procurement. Under the system, AFSC can evaluate hardware concepts that originate in any Air Force command or as industry proposals.

Schriever described the limitations of Project 1559 in a speech last October to the National Space Club: "This project cannot buy development, but it can acquire prototypes. It cannot accommodate production, but it can acquire sample quantities of promising end items."

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The non-development aspect of the project makes it particularly useful for meeting the demands of limited war, in that hardware to be bought and tried must be available within six months to qualify for procurement.

It is not intended specifically to met the funding needs of the Air Force in Southeast Asia, but has been useful in providing the quick-response buy, test and try capability demanded in that combat environment.

Project 1559 was funded at $500,000 in FY '65, but jumped drastically to $6 million in FY '66. Another $1 million may be pumped into the program with funds from the FY '66 supplemental request.

Some 77 tasks had been documented under Project 1559 through early March, ranging from target-marking techniques to improved rescue and survival equipment.

Project 1559 funding almost always dictates sole-source procurement, since in most cases the hardware is in being when Project 1559 funds are committed for procurement.

The Deputy for Limited War at ASD has authority from AFSC to procure Project 1559 items with values of $25,000 or less. Air Force headquarters must give authority to proceed with tasks that would cost more than $25,000.

The Project 1559 fund has already shown its quick-reaction flexibility by expediting a number of Air Force efforts in Vietnam. Some $230,000 from Project 1559 went toward adapting the Northrop F-5 aircraft to accommodate the KA-60 strike-assessment camera for use in Project Skoshi Tiger.

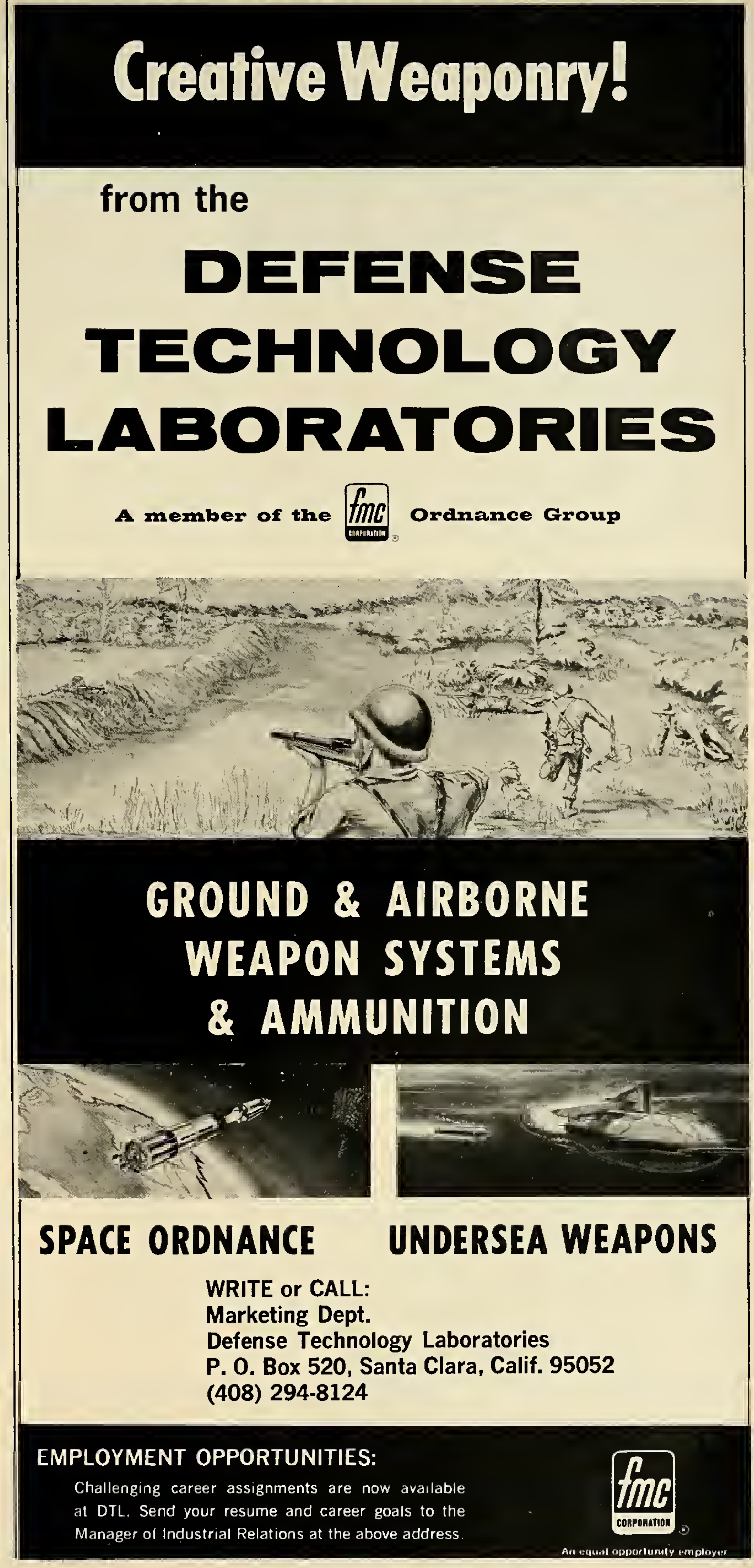
Another Project 1559 undertaking resulted in Air Force adoption of the Army's combination of the AR-16 rifle with a grenade launcher for use in base security in Vietnam.

The quick-reaction theme running through all these systems is evident in the reliance on electrical communication to transmit requests from the theater of operations to higher headquarters and back. Paper authorization always follows to confirm TWX or telephone messages, but a climate of confidence has developed in authority to proceed with procurement or development based on electrical communication alone.

ARMY

The same climate of confidence in "interim" authority to procure hardware for limited war evident in the Air Force has been growing in the Army since activation in 1962 of the Limited War Lab at Aberdeen Proving Ground, Md.

As one source in the Office of the Chief of Research & Development puts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it, "We've begun to break down the bureaucracy" that formerly necessitated an R&D cycle of five to seven years before an item was standardized and placed in the Army inventory.

Chiefs of components in the field now know that they have quick access to OCRD, whether they be theater commanders or battalion commanders.

Establishment of the Limited War Lab predates the increased involvement of U.S. forces in Vietnam, but 90% of LWL's effort is now directed at finding solutions to problems that develop in Vietnam. The lab's effectiveness is attested to by one Army source who says it will remain as an immediate arm of the Army chief of R&D, Lt. Gen. William W. Dick, Jr., "even if the war in Vietnam ends tomorrow."

LWL officials have authority to go into development of any item costing less than $200,000 without first getting approval from Gen. Dick. In addition, any project engineer at LWL may spend up to $1,500 on a promising idea without consulting his immediate superior. This freedom is encompassed in the lab's GNI (generation of new ideas) program.

The project engineer's idea might result in a 30-day funded study with industry to determine the feasibility of the concept, and ultimate procurement of hardware to implement the concept. These encouragements to initiative have begun to shorten the R&D cycle from the traditional five to seven years to the 6 to 18-month response capability demanded by limited-war situations.

Procurement time has been shortened, too, because communications channels between the field army and the procuring agency are more direct than ever before.

Quick-reaction system—The Army has had a special-warfare project manager since November, 1962. The job is presently held by Col. Robert E. Lutz, Army Materiel Command, but it has been expanded and refined considerably since Lutz assumed the responsibility.

Lutz has two principal vehicles at his disposal to meet the mounting demands of the Army in Vietnam: the Army Materiel Command's quick-reacting procurement system (QRPS), and the system that encompasses procedures for expediting non-standard urgent requirements for equipment (ENSURE).

QRPS is a "quick-reacting, responsive purchasing and delivery system for commercial-type items in support of special warfare activties." The ENSURE system allows the special-warfare project manager to expedite supply of "material requirements for non-standard and developmental equipment to support U.S. Army forces engaged in active military operations." The latter system also covers materiel items not available in the Army inventory.

QRPS is a focal point for requirements originating in ARPA/Agile, and ACTIV (Army Concept Team in Vietnam) that are to be fulfilled by the Army Materiel Command. The special-warfare project manager works through three procurement sources to fulfill QRPS requirements. They are the Army's Natick Laboratories, Natick, Mass.; Aberdeen Proving Ground, Md.; and Edgewood Arsenal, Md., near Aberdeen.

Natick Laboratories procures soft goods (subsistence, clothing and related quartermaster-type items) under QRPS. Aberdeen secures hard goods (weapons and non-quartermaster-type items) under QRPS. The Aberdeen procurement office also is the purchasing agent for the Limited War Lab, and the special-warfare project officer is responsible for channeling into the standard inventory those items developed by LWL that might have widespread usage.

Edgewood Arsenal, with a larger legal and pricing staff than Natick Labs and Aberdeen, is responsible for procurements involving large-quantity buys—purchases exceeding $100,000. The original guidelines established for Natick and Aberdeen in limited-war hardware procurement set $100,000 as the ceiling on QRPS purchases through those installations.

Latitude—The broad charter given the special-warfare project manager allows him discretion to use funds from several sources. Chief among them is about $1 million a year in O&MA (operations and maintenance, Army) funds available within AMC. But he also has control over four other Department of the Army funds: 1) communications and electronics items for special warfare; 2) guerrilla warfare countermeasures equipment; 3) guerrilla and demolition ordnance, and 4) guerrilla countermeasures techniques.

In most cases, however, a "fund citation" accompanies a hardware requirement channeled to Lutz's office allowing procurement with the using agency's money.

Requirements coming from U.S. Army, Vietnam, are forwarded through the Counterinsurgency Support Officer, U.S. Army, Ryukyus, who is charged with support of Army forces in Vietnam. If QRPS is to be used, the procedure for fulfilling the requirement is this:

The request is directed through the commanding general, Army Materiel Command, to the attention of the project manager for special warfare. The

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requirement is usually made known by TWX message. Information copies are sent to the Deputy Chief of Staff for Operations (DCSOPS).

The QRPS machinery has been instrumental in speeding needed hardware of all kinds to Vietnam. One request from special-forces personnel was for 12 airboats to skim across marshy terrain. These are not in the Army inventory, but were purchased from two U.S. firms for evaluation.

They have been so effective against the Viet Cong that a request for 30 more came to Col. Lutz's office in early March. Some of them may be in the hands of the special-forces users for training by May.

In theory, then, the quick-reacting procurement system functions somewhat like the Air Force's Project 1559, in that it is intended to answer requirements for special warfare hardware that can be obtained commercially and quickly.

ENSURE—The ENSURE system is roughly analogous to the Air Force SEAOR procedure, because it is designed to meet the needs for non-standard hardware requested by units actually engaged in combat.

In practice, both systems are being applied primarily to answer requests originating in Vietnam, because, as one observer phrased it, "that's where the action is."

NAVY

Navy planners interviewed by M/R indicated that the service's traditional ways of operating are not seriously affected by operations in Vietnam. Some procedures have been refined, and at least one team of trouble-shooters has come into being, but the team's Vietnam efforts are superimposed on previously existing duties.

A Southeast Asia Programs team has been set up in the Office of Program Appraisals at the Chief of Naval Operations level. The team is known informally as the Navy's "Mother Hubbard" team. It consists of about 25 specialists, many of them in the various Navy systems commands, whose task it is to pinpoint programs in which monies allocated for expenditure in the current fiscal year are not likely to be spent.

The Mother Hubbard team then brings these "available" funds to the attention of the CNO, who may request that the money be reprogrammed into Southeast Asia efforts before the end of the fiscal year. Southeast Asia programs may run the gamut from aircraft ordnance to underwater demolition team equipment.

Indeed, aircraft ordnance consumption is one of the Navy's biggest cost items in the war in Vietnam, and the material requirements branch office of

"go where the action is"...
has peculiar significance for

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M & R Editors Win Coveted Neal Award

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1965

Missiles and Rockets, The Weekly of Advanced Technology, received the Jesse H. Neal Editorial Achievement Award for 1965. The award, the most cherished in business publishing, was presented to the editors of Missiles and Rockets for the best feature article or series of feature articles in all ABP member magazines with circulations of more than 40,000. Our winning entry was the September 6, 1965 "Special Report on Oceanology—exploiting and exploring the seas."

Missiles and Rockets—An American Aviation Publication
1001 Vermont Ave., N.W., Washington, D.C. 20005

the DCNO for logistics has been directed to "review, monitor and expedite" Southeast Asia requirements—particularly ordnance consumption.

The branch has updated the fleet's ordnance consumption reports—putting them on a bi-weekly basis instead of the peacetime quarterly system previously in use. These are circulated throughout the Pentagon to meet and anticipate ordnance expenditure levels.

One of the things pointed out by the ordnance consumption reports is that the 5-in.-dia. *Zuni* air-to-surface rocket has been used more extensively than anticipated in Vietnam operations. The rocket has been equipped with a proximity fuze that makes it a more versatile weapon against such targets as trucks, bunkers and personnel concentrations.

The Navy, too, has found ways to shorten the time it takes to get top-level approval to meet requirements coming from Vietnam. The service has substituted a memorandum system for the former program change proposal (PCP) when quick response is needed.

Reactivation of the 755-bed hospital ship USS Repose, now on station near Chu Lai, was triggered by a memo from the CNO to the Secretary of the Navy, who then forwarded it to the Secretary of Defense. Using memos, the procedure required about a week. It might have required one to three months under the PCP method.

MARINE CORPS

The Marine Corps is establishing for the Third Marine Amphibious Forces a reporting procedure which it feels will get the information on special R&D requirements from Vietnam back to headquarters. Requirements might include hardware, tactics and techniques.

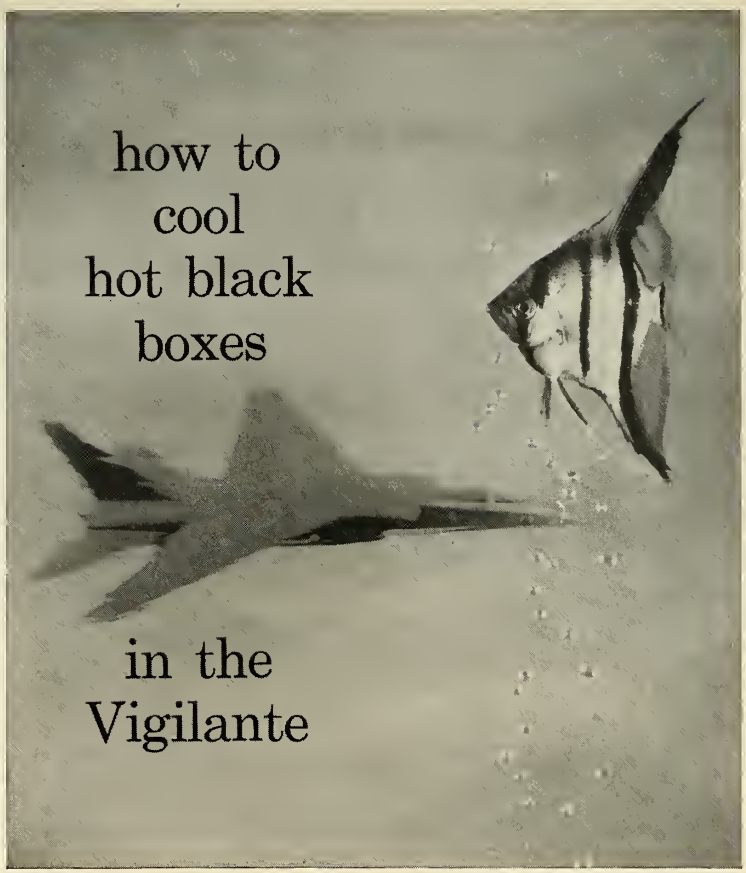
A group of R&D specialists is sent to Vietnam every other month to look into the significant problems that might be better solved in the U.S. than at a fleet Marine force headquarters, and to carry back requirements to the United States.

In addition, requirements are reported regularly by Lt. Gen. Victor Krulak, commanding general of the Fleet Marine Force, Pacific.

The special team, usually five or six officers, is composed of experienced veterans such as pilots and infantrymen who can understand the problems involved.

Testing of equipment that may go to Vietnam usually takes place at the Marine Corps Fleet Development Center at Quantico, Va.

Contracting is done through the regular Marine channels, sometimes unilaterally, sometimes jointly with other services, and through the Navy system commands. ■



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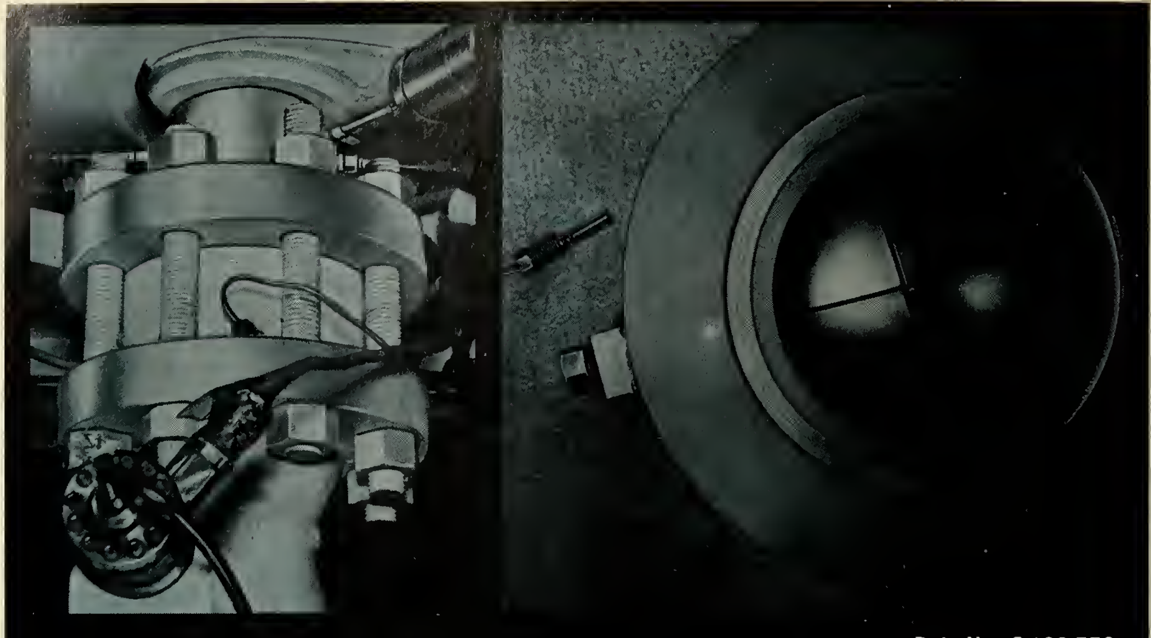

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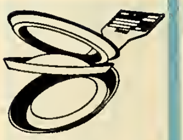

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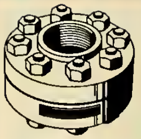
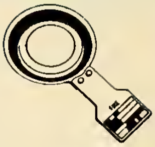


RUPTURE DISCS WITH ASA BOLTED FLANGE ASSEMBLY



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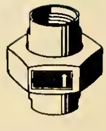

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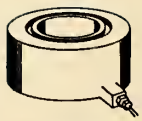

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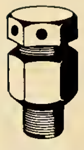

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Limited-War Funding Continues Surge

FY '68 DOD budget to rise even without broader Vietnam war; greater troop commitment could trigger FY '67 supplemental

by Hal Taylor

EVEN IF THE VIETNAM WAR continues at its present pace, the Dept. of Defense budget in Fiscal Year 1968 is expected to be higher than the FY '67 request of $57.2 billion.

DOD officials also report that almost all of the increased funding will be used to support limited-warfare projects, since spending on strategic warfare systems is expected to remain level.

At the same time, the department will have to ask for an FY '67 supplementary budget if the U.S. troop commitment to South Vietnam reaches 400,000 men, as some observers have predicted. The $57.2-billion level will support a force of only some 300,000.

DOD officials stress that if, on the other hand, the Vietnam war should end, U.S. industry should expect funding for limited-warfare projects to decrease in direct proportion to its increase with the escalation of the war.

One major exception may be the helicopter program. The successful use of the craft in Vietnam may mean that other U.S. Army and Marine divisions may be transformed into Air Mobile Divisions.

The current upsurge in procurement for limited-warfare projects will stop only if the war situation is resolved to the point that there is a certainty of no further active engagements. If there is a mere cease-fire—with the possibility of resumption of hostilities—it is doubtful that this country will reduce the size of its armed forces —which will grow from 2,653,000 at the end of FY '65 to 3,093,000 at the end of FY '67.

As for FY '68, officials say there will be a rise in the budget even if the number of troops in Southeast Asia remains at the current level, simply because their rate of active operations is likely to increase.

Two problems—The officials admit that they have two major problems in budgeting for limited warfare.

One is the inability to break down within the DOD budget exactly how much is spent for limited-warfare programs and how much is earmarked for strategic offensive and defensive forces.

The second is the inability to predict what the level of activity in a limited war will be in a future year, even if it is only six months away.

The first problem is glaringly evident simply because DOD has never attempted it. They have not done it, officials report, because there is no apparent way to determine exactly how much, for example, of the $16.7 billion in general-support funding would be used for a limited war and what would be used to support strategic forces. As a further example, they say that if you attempted to prepare such a breakdown, it is likely that you would put the $5.1-billion request for strategic offensive forces on the strategic side of the ledger. Then they note the successful use of the B-52 strategic bomber as as offensive tactical weapon in South Vietnam.

One rough method of breaking down the budget, however, results in total expenditures of $41.7 billion for limited warfare.

That total is reached by assigning to limited warfare all of the $25.7 million budgeted for general-purpose forces —$2.1 billion for airlift/sealift forces, $2.4 billion for Reserve and Guard forces, the estimated 46%—or $2.5 billion—in research and development funds committed to brush-fire wars, 50%—or $8 billion—of the general support funds, and the $1-billion military assistance program.

The strategic warfare total would include $5.1 billion for strategic offensive forces, $1.4 billion for continental air and missile defense forces, and 50% —or $8 billion—for general-support forces.

This is an admittedly rough breakdown because it is certain that some of the large general-purpose force would be used in a strategic war. It is also true, however, that they are available for use in limited wars. Also, there is no apparent way of determining exactly what per cent of the general-support funds are earmarked specifically for either type of war.

DOD officials are far more certain of the special costs of the Vietnam war. One such spokesman said that in FY '66 a total of $14 billion will be spent specifically to fight that war. The total includes $1.7 billion in the regular budget and all of the $12.3 billion requested in the supplemental. In the next fiscal year, they say, $10 billion of the total of $57.2 billion will be used in Vietnam.

The second problem—Estimating a future year's requirements in a limited war is considered a much more difficult problem because so much depends upon the action of the enemy.

It is hard to predict not only whether the enemy will escalate or de-escalate, but also exactly how the U.S. will want to respond to actions which could take place as much as 18 months in the future.

For example, DOD officials refer to the unexpectedly large size of the $12.3-billion supplemental budget request in 1966. This budget was first prepared in August, 1965, with only about two months experience on the consumption and attrition rate of the growing U.S. force in South Vietnam.

The August estimate was that the supplemental would have to be in the $3 to $5-billion range. Later it had to be more than doubled—simply because the rate of active operations in South Vietnam was far higher than expected.

Procurement—The DOD FY '67 budget includes $17 billion for procurement of equipment and supplies which could be used in fighting a limited war. Much of it is specifically intended for Vietnam.

The total for next year is higher than the FY '66 budget of $15.46 billion, primarily because much of the funds obtained in the FY '66 supplemental will not be spent until FY '67.

The service showing the largest increase in 1967 is the Army—primarily because of the increased need for combat and support equipment and ammunition for forces in Southeast Asia; it will jump from $2.5 billion in '66 to $3.3 billion in 1967.

Army procurement (FY '66 total first, followed by '67 request) includes: aircraft, $412 million, $511.9 million; aircraft spares and spare parts, $78 million, $94.4 million; missiles, $250 million, $305.6 million; missile spares and repair parts, $21 million, $22.3 million; tracked combat vehicles, $304.7 million, $342.6 million; weapons and other combat vehicles, $37.8 million, $42.9 million; tactical and support vehicles, $360.5 million, $474.8 million; communications and electronics equipment, $228 million, $278.4 million; and other support equipment, $127 million, $241.1 million.

The cost of the Vietnam war is graphically illustrated by the almost 100 per cent jump in Army ammunition procurement—from $568 million to $1.028 billion.

Army aircraft procurement program is designed to meet its need for battlefield observation, troop movement, medical evacuation and rapid logistical and tactical support for troops engaged in combat. It also includes large additional quantities of helicopters.

Among the missiles which will be purchased in the 1967 procurement program are the *Redeye, Nike-Hercules, Hawk, Shillelagh, Lance* and *Chaparral.*

Total Navy procurement for aircraft and missiles, excluding *Polaris* and *Posideon* ballistic missiles, is dropping sharply in the next fiscal year—to slightly below $2 billion, compared to about $2.5 billion in 1966.

The breakdown includes: combat aircraft, $1.3 billion, $875.8 million; trainer aircraft, $95.5 million, $83.5 million; other aircraft, $23.9 million, $39.9 million; modification of aircraft, $197.3 million, $183.6 million; aircraft spares and spare parts, $538.8 million, $465.5 million; aircraft support equipment and facilities, $66.8 million, $71 million; other missiles, $214.9 million, $229.2 million; missile spares and repair, $21.9 million, $21.3 million.

The 1967 aircraft procurement program provides for procurement of additional carrier-based attack aircraft, land-based antisubmarine aircraft, antisubmarine helicopters and helicopters to support Marine assault missions. The smaller missiles include the first full production of the new *Standard Missile* as well as continued procurement of *Talos* and support items for *Tartar* and *Terrier.*

In its ship-building program, the Navy expects to spend in the next fiscal year $345 million for amphibious ships and $280 million for mine warfare and patrol ships.

Other FY '67 procurement for the Navy includes: $125.2 million for ammunition and ordnance equipment; $3.7 million for tracked combat vehicles; $16.5 million for guided missiles and equipment; $59.6 million for communications and electronics equipment; and $39.1 million for support vehicles.

Marine procurement in Fiscal Years '66 and '67 provides primarily for ammunition, *Redeye* missiles, and other equipment for use in Vietnam. It includes: ammunition, $314.6 million, $23.6 million; guided missiles and equipment, $25.8 million, $1.7 million; communications and electronic equipment, $14.2 million, $28.4 million; and support vehicles, $47 million, $13.5 million.

Total Air Force procurement is also rising, from $3.76 billion to $4 billion.

The increase in the buy of combat aircraft—from $1.3 billion to $1.5 billion—reflects the procurement of the F-111 tactical fighter as well as initial procurement of the FB-111 strategic bomber. While the latter is primarily designed for use in strategic wars, it is conceivable that it could be used in a limited war—just as the B-52 bomber is being used in Vietnam.

Other Air Force procurement includes airlift aircraft, $439.3 million, $524.7 million; trainer aircraft, $40.6 million, $8.9 million; other aircraft, $76.4 million, $49.5 million, modification of inservice aircraft, $559.4 million, $480.1 million, and aircraft spares and repair parts, $600.7 million, $767.6 million.

Air Force procurement of small missiles will rise from $35.1 million to $75.5 million, including purchases of the *Shrike* anti-radiation missile, the *Bullpup B* air-to-ground missile, the *Sparrow* air-to-air missile, the *Falcon* air-to-air trainer, and *Firebee* drone.

Huge base camp and helicopter landing apron for the Army's First Cavalry (Airmobile) Div. at An Khe was carved out of jungle in a few weeks. Division now uses one brigade to defend camp and two for seeking enemy. (M/R photo.)

Again reflecting the intensified war in Vietnam, Air Force procurement for munitions and associated equipment will show a tremendous jump—from $529.8 million to $1.4 billion. Other procurement includes: vehicular equipment, $80.4 million, $61.6 million; and electronics and telecommunications equipment, $370.5 million, $224.9 million.

Research and development—Officials of the DOD Directorate of Research and Engineering are far more specific than other Pentagon officials as to what portion of their budget will be used for limited-warfare programs. Following a study of their budget, they estimated that 46%—or $2.5 billion—is going into limited warfare R&D.

About $1.7 billion of that total is spent on programs in DDR&E under the direction of Thomas P. Cheatham, deputy director for tactical warfare programs.

Of that total, some $188 million will be used to fund special-warfare and counterinsurgency R&D programs. The 1967 total compares with funding levels of $184 million in 1966 and $173 million in 1965.

Another $200 million is allocated to Project PROVOST, a special program devoted to finding answers to specific problems in terms of weapons or counter weapons which develop during the Vietnam fighting (see p. 132). Once the requirement for a new weapon or detection device or other special needs are sent from Vietnam, the PROVOST program provides that the problem be out of DDR&E and on its way to either the Army, Navy, Air Force or Marine Corps for a solution within 24 hours.

In the special warfare and counterinsurgency area, the tactical programs office is earmarking $32 million in FY '67 for development of new reconnaissance and surveying devices. In FY '66, about $29 million was spent in the same area.

Funding for special night-operations techniques will increase from $12 million this year to $16 million next year.

New air-to-ground attack systems funding will drop from $30 million this year to only $20 million next year—primarily because of the completion of development of the OV-10 aircraft. Funding of mobility and logistic systems will increase slightly—from $18 million to $20 million. The development of non-lethal weapons will cost about $26 million in both 1966 and 1967.

R&D for new communications equipment will rise to about $6 million and development of other limited-war firepower will be funded in 1967 at the $13-million level. Other items include $19 million for new medical supplies, $15 million for special non-material research, and $19 million for a special-warfare laboratory fund.

In the exploratory development area of the DDR&E program, a large part of the $232 million being requested by the Army will be devoted to techniques or equipment directly applicable to front-line combat, with emphasis on communications and electronics, ordnance and medicine. More specifically, this work includes electronic counter-countermeasures, radios, antennas and survival kits specially adapted to operations in tropical jungles, and light intensifiers for night vision devices.

Money will also be spent for experimental radars, technology to increase combat surveillance investigations of new boats for assault operations, and emplacement of bridges, new vaccines, techniques to treat burns and prosthetic devices.

The Air Force is spending about $53 million for the improvement of surveillance techniques, paying particular attention to perfecting photographic, infrared, and electronic over-the-horizon capabilities.

It is also spending another $10 million in continuing work in such areas as improving the arming and fuzing of conventional ordnance, better lightweight, high-strength alloys, and investigating gravitational and geodetic problems.

The Navy expects to fund new exploratory development programs in the surveillance and navigational area at a total cost of about $80 million. Another $44 million will be used for development of new design concepts for naval vessels, captured air-bubble ships, buoy sonar domes, hydrofoil craft, and new hulls able to penetrate the ice more easily.

In the advanced-development area of R&D, DOD plans to spend a total of

(Continued on p. 147)

USS Enterprise, operating off the coast of South Vietnam, launches an F-4B from left catapult while two A-4E's line up on right. An RA-5C photo reconnaissance aircraft will follow the F-4B into air on strike against Viet Cong. (M/R photo.)

collage

More Motorola mishmash, continued from page 96

ONCE MORE INTO THE I/C BREACH
ONCE MORE INTO THE I/C BREACH

(and leave on your beard)

This seems to be our month for pushing Motorola's integrated circuitry capabilities. Don't be offended. If you could apply I/C like we do, you'd brag too. And if you *can*, our employment office has assured us you won't have to shave off your beard or even take a Rorschach. Anyway, now we want to speak of RIC, or Radar Interceptor Calculator for the Rome Air Development Center.. What's so elegant (to use PhD talk) about RIC is that it uses 3,000 integrated circuits to do the work of 12,000 conventional circuits. Unless you happen to be in the conventional circuit biz, you'd have to admit this is great. The calculator works with a PPI scope to furnish a semi-automatic target tracking and intercept prediction capability. It's only ⅓ cu. foot small. If we sold them by the pound we'd go broke. Write Chicago Center for details.

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WESTERN CENTER
8201 E. McDowell Rd., Dept. 2, Scottsdale, Arizona

Procurement Contacts for Limited War

FOLLOWING is a list of key persons within the military services concerned with procurement for limited or special warfare.

The Navy listings are subject to extensive revision if Congress approves the recently announced reorganization.

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BRIG. GEN. ROBERT H. McCUTCHEON
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Headquarters, Air Force Logistics Command
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NAVY

Bureau of Weapons

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AIRFRAMES DIVISION
Robert S. Young
1610 Munitions Building
Washington, D.C. 20360
Phone: Code 202 OX-6-3568

COMPONENTS AND UNDERWATER SYSTEMS DIVISION
Julian A. Ross
1606 Munitions Building
Washington, D.C. 20360
Phone: Code 202 OX-6-4510

CONTRACT ADJUSTMENTS DIVISION
J. J. Mulligan
1633 Munitions Building
Washington, D.C. 20360
Phone: Code 202 OX-6-5119

MISSILES SYSTEMS DIVISION
J. W. Frankl
1608 Munitions Building
Washington, D.C. 20360
Phone: Code 202 OX-6-2718

Bureau of Ships

CONTRACT DIVISION
CAPT. G. C. WELLS
Room 3054
Main Navy Building
Washington, D.C. 20360
Phone: Code 202 OX-6-2112

SHIPBUILDING AND REPAIR PURCHASE BRANCH
C. W. Brockman
1N39
Main Navy Building
Washington, D.C. 20360
Phone: Code 202 OX-6-2281

ELECTRONICS PURCHASE BRANCH
B. J. Pyrek
1N47
Main Navy Building
Washington, D.C. 20360
Phone: Code 202 OX-6-1803

MACHINERY PURCHASE BRANCH
Coleman Morris
1N11
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MARINE CORPS

J. W. McLAIN
Mail Code CSG-4
DIRECTOR OF PROCUREMENT DIVISION
Headquarters Marine Corps
Navy Annex
Washington, D.C. 20390
Phone: Code 202 OX-4-2582

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$72 million on V/STOL aircraft program in an effort to solve such problems as stability and control, static thrust deficiencies, vibration, noise, and reliability of components—particularly in the power transmission system.

Another $4 million in advanced development funding is being requested for aircraft suppressive fire systems, which will be used to translate some new concepts into prototype hardware.

The Navy is asking for $2 million in FY '67 funds for the landing-force support weapon (LFSW), which will be used to flight-test the Army's *Lance* missile in a sea environment.

The Air Force is requesting $6 million for reconnaissance strike capability project with the objective of developing multiple high-resolution sensors such as side-looking radar, high altitude/high-resolution radars, forward-looking IR sets, and optical image enhancement for low-light-level conditions.

Engineering projects—In the engineering development area the Army is requesting $46 million to continue development of the Special-Purpose Individual Weapon (SPIW), the medium anti-tank weapon (MAW) system, and the 155mm lightweight close-support weapons system.

About $14 million will be used by the Army to fund a new hand-held radar and the development of sound-ranging equipment to help locate hostile weapons in forward areas.

The Air Force engineering development program includes $4 million for the FX Close Support Fighter. The money will be used to continue preliminary studies of an advanced fighter attack aircraft for both the Air Force and the Navy.

Funds are also included for continued development of the YF-12A and the ASG-18/AIM47A fire-control and air-to-missile systems already installed in that aircraft and for the adaptation of these systems to the F-12 airframe.

It is also indicated that DOD expects to select a contractor in the next fiscal year for the Mark II avionics project, which is to serve as a replacement for the present avionics system on the F-111.

Another $11 million has been requested for the Joint Advanced Tactical Command and Air Control System, which will develop a family of standard equipment such as displays, computers and communication items for use in the tactical command and control systems of all the services. It is hoped that use of integrated circuits will hold system failures to 10%. The funds requested will be used to initiate the development phase and permit the determination of the joint funding program among the services for future years. ■

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When inertia begins to replace interest, you're in trouble. No drive, no accomplishment, no advancement. There's no room for boredom at Hamilton Standard. We offer state-of-the-art activity in Space Life Support, Electronics, Ground Support Equipment, Environmental Control Systems, Electron Beam Welding Machines, much more! We need wide-awake, ambitious engineers of almost every engineering discipline. We can offer an exciting working environment, and the refreshing family living in the beautiful Connecticut countryside. Typical opportunities:

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RELIABILITY/MAINTAINABILITY ENGINEERS

OPERATIONS RESEARCH/SYSTEMS EVALUATION

ADVANCED PLANNING ENGINEERS

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for such specialties as Fluid Dynamics, Thermodynamics and related disciplines.

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for such specialties as Hydraulic/Pneumatic Systems, Freon/Refrigeration Systems.

MACHINE DESIGNERS
for Electron Beam Welding Machines.

METALLURGISTS
Welding Engineers

ELECTRONIC ENGINEERS
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Systems Design (Digital Simulation)
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Goddard Cryogenic valves have been used for thousands of leak-free cycles and have consistently exceeded customer requirements.

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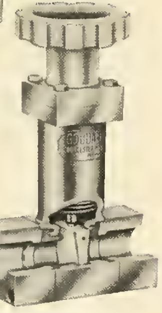

The Goddard valve features high conductance and unrestricted flow. Bellows sealed for pressures to 1 x 10^{-8} torr. Replaceable Kel-F Seats.

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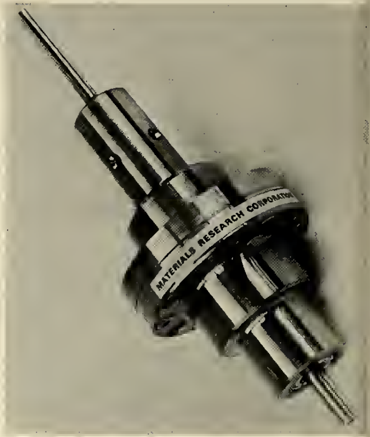
Circle No. 40 on Subscriber Service Card

New Product of the Week: Magnetic Feed-Thrus



Two magnetic rotary feed-throughs that permit rotation in systems with vacuum greater than 10^{-7} torr have been announced by Materials Research Corp.

Model V4C-101M is capable of speeds up to 5,000 rpm and torque up to 2 in.-lbs. Model V4C-102M has rotational speed of up to 15,000 rpm and torque rated at ¼ in.-lb.

Both units will mate with standard high-vacuum commercial flanges. They are bakeable to 250°C when operating and 400°C non-operating.

Circle No. 151 on Subscriber Service Card

Damping Material

A two-part resin-based damping compound suitable for use on metal or plastic to reduce structure-borne vibrations and noise has been announced by the Soundcoat Co., Inc.

The GP-5 compound is available in paste form and sheet form. As a thin coating, it will provide damping to eliminate tinniness in metal; heavier treatments will provide damping for severe vibrations.

In sheet form, the material is available in 5, 10 and 40-lb. batches and can be die-cut to specifications.

Circle No. 152 on Subscriber Service Card

Frequency Converters

Del Electronics Corp. has announced a line of precision frequency converters with output power ranges from 100 to 1,000v ac.

The ATA series is a completely solid-state source of stable 400-cycle power operating directly from a standard 50 to 70-cycle line. Voltage regulation, from no-load to full-load, is 0.5%. Line regulation is ± 0.5% for a line change from 105 to 125v.

Circle No. 153 on Subscriber Service Card

Microwave Receiver

Development of a microwave receiver that can screen out unwanted signals has been announced by Sylvania Electric Products, Inc.

The electronically tunable Model R-31 contains a yttrium iron garnet (YIG) crystal filter that selects the desired signal and rejects others. The YIG crystal is capable of passing microwave energy on a narrow bandwidth to filter signals not on the tuned frequency.

The unit can be tuned either to a specific frequency or set to scan a wide bandwidth and locate the desired signal.

Circle No. 154 on Subscriber Service Card

MIG Welding Process

A pulsed-power MIG welding process for high-quality welding in overhead and vertical positions has been introduced by Air Reduction Co.

The "Pulsed Arc" power supply combines two d-c power units in one cabinet. The two units work together to provide a continuous arc between the wire electrode and the work.

A standard, three-phase power unit supplies background current and a single-phase power unit supplies a high-intensity current that pulses 60 times per second. The supply switches back and forth between the two currents with

the background current maintaining the arc and heating the wire and weld joint. During the pulse current cycle, the weld metal is sprayed evenly across the arc and deposited in the weld joint.

Circle No. 155 on Subscriber Service Card

Temperature Indicator

A thermistor-type temperature indicator with response time of 3 sec. and accuracy better than 2% of full scale has been introduced by General Transducer Co.

The touch-and-read hand-held Thermi-tem features expanded meter scales with total range of 50° or 100°F full-scale. The ranges available can be specified anywhere in the total temperature band —50° to 500°F. Readability of the 50-degree scale is ½°; that of the 100-degree scale is 1°.

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BATTERY ADJUST
ON-OFF
ADJ

Circle No. 156 on Subscriber Service Card

Transfer Function Analyzer

An automatic transfer function analyzer featuring analog and digital outputs has been announced by Canoga Electronics Corp.

The Model 950 Servodyne provides an automatic method for determining the low-frequency transfer function characteristics of any three- or four-terminal network. The unit accepts a signal from any point in the system under test and compares the phase and amplitude of the test signal with the precisely defined sinusoidal forcing function. By making such comparisons at different frequencies, the complete network transfer function can be evaluated.

Measured data, forcing function frequency, and amplitude are provided simultaneously in digital and analog form, enabling network phase and gain plots to be made while test data is recorded digitally.

Forcing function amplitude may be preset with ±2% accuracy from 10 mv to 10v peak; frequency is adjustable from 0.1 to 99 cps. Ratio of drive-to-test signal amplitude is measured with ±0.5-db accuracy over a 60-db range. Phase of the test signal is measured over 180 degrees with ±1.5° accuracy. Effect of harmonic distortion in the test signal is limited to 0.005-db ratio error and 0.05° phase error per % harmonic content.

Circle No. 157 on Subscriber Service Card

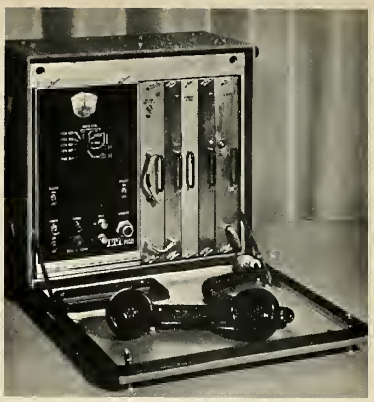
Coaxial Couplers

A line of directive coaxial couplers has been developed by Microlab/FXR.

The CB series of three-port or four-port couplers offers directivity of 25 db over a full octave frequency range, with ± 1 db coupling variation. The units are available in 10, 20, and 30-db coupling values with a mainline VSWR of 1.15 and with type N and TNC connectors. Six units cover from 200 to 4,000 mc in overlapping octave bandwidths.

Circle No. 158 on Subscriber Service Card

Communication Terminal

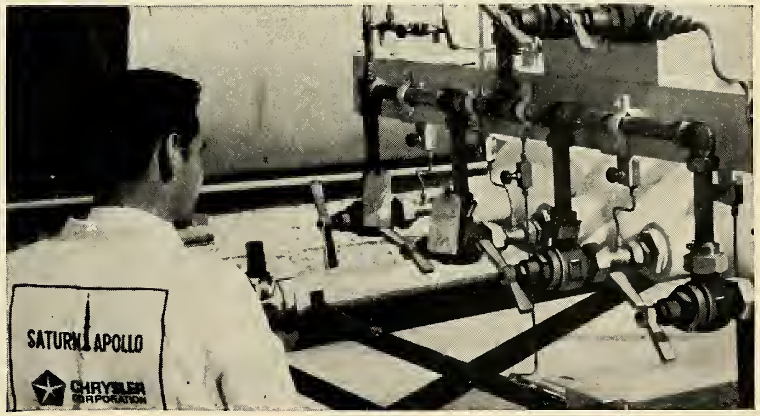


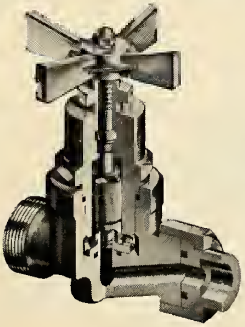
A portable two-way microwave communication terminal that can carry multichannel voice, data, television or radar signals has been announced by International Telephone & Telegraph Corp.

The microelectronic Pico CXL-series terminal contains a receiver, transmitter, order-wire internal signaling, handset, high-gain planar array antenna, and battery-operated power supply. The unit is completely integrated and can be operated as a single or multihop system.

The terminal can operate from an a-c power supply or a pack of nickel-cadmium rechargeable cells. It is available in four configurations complete with power sources.

Circle No. 159 on Subscriber Service Card





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Circle No. 41 on Subscriber Service Card

A-C Voltage Standard

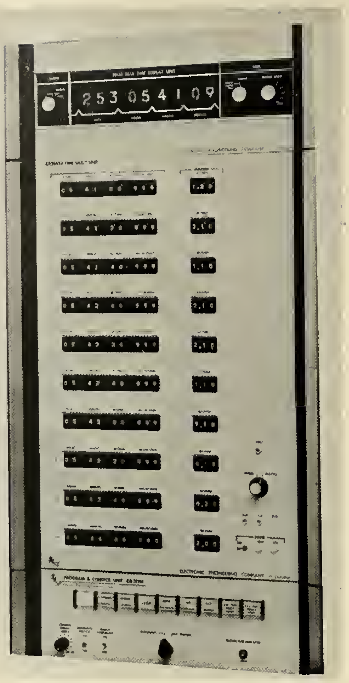
Weston-Rotek Div. of Weston Instruments, Inc. has developed what it claims to be the first true absolute a-c voltage standard.

Model AV10 features a continuously variable internal oscillator with a range of 38 to 11,000 Hz. It has an output voltage range of 0 to 511.110v rms, and true absolute accuracy of 0.025%. Harmonic distortion is 0.01%; the all-solid-state modular unit is convection-cooled.

The instrument has a calibration accuracy of 0.01% from 380 Hz to 1 KHz. Resolution is 1 mv from 380 to 11,100 Hz, 100μv from 38 to 379 Hz. Maximum full load regulation is ± 0.01% from 151 to 511.110v, ±0.01% for 10-v steps from 51 to 150v, and ± 20 milliohms for 10-v steps from 1 to 5v. No recalibration is required after replacement of the fuse if overloading occurs. Maximum output inductance of the unit is 0.2 mHz.

Circle No. 160 on Subscriber Service Card

Tape Search System



A large automatic search and control system for finding and reproducing data on magnetic tape has been announced by Electronic Engineering Co.

The system enables an operator to select up to 10 segments of data recorded on a single roll of magnetic tape by setting 10 sets of thumbwheel switches to the time recorded on one track of the data tape.

The tape reproducer moves in either direction until the time code on the tape corresponds to the time selected. It then reproduces the data on the tape at normal reproduce speed for a selected number of seconds.

The time code setting has a resolution of hours, minutes, seconds and milliseconds. Reproduce duration may be from 0.01 to 9.99 seconds.

Circle No. 161 on Subscriber Service Card

Single-Turn Potentiometer

A potentiometer with resistance ranges from 10 to 100K ohms has been introduced by Amphenol Controls Div.

The single-turn 2560 unit has resistance tolerance of ± 5% from 10 to 5K and ± 3% from 10 to 100K. Power rating is 2 full watts at 85°C. It is gangable with up to 8 cups and withstands temperatures up to 150°C.

The instrument is wirewound and offers ± 0.5% independent linearity. Both the element contact and commutator contact are dual-design wipers. Redundancy in the contact mechanism prevents open circuits even when subjected to 50 g's shock or acceleration, according to the firm.

All phasing and zero settings can be accomplished in the field. The servo-mounted pots are equipped with precision, stainless-steel ball bearings for low-torque requirements. The firm guarantees a rotational life of 2,000,000 revolutions. The potentiometer meets MIL-R-12934D specifications.

Circle No. 162 on Subscriber Service Card

Gas Chromatograph

A chromatograph developed for medical, bio-medical and research laboratory use has been announced by Fischer & Porter's Lab-Crest Div.

Model 310 is a self-contained, bench-top unit comprising columns, detectors, ovens, and a combination d-c power supply/electrometer package. It accepts interchangeable plug-in detectors for argon ionization, hydrogen flame and electron capture. On-column injection is made through an aperture in the column lid.

The low-mass column oven has a patented cooling system that insures rapid change of column temperature without loss of equilibrium or temperature gradient, the firm claims.

Oven temperature is dialed, read directly, and held within 0.5°C by a

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Except... when it's a rugged stainless steel, trunnion mounted, full ported, 3 inch model that opens and closes like butter at 4,000 psi. ***And...*** when it stays leakproof from 4,000 all the way down to 0 psi. The DYNAFLOW VB2142 seals tightly in either direction, closed or open. It really couldn't care less. Swing the handle one full turn and it stays put. Austenitic stainless steel for wetted metal parts. Seals and bearings are Teflon tough. Handles helium, hydrogen, nitrogen, water, hydraulic oil and most common fluids at temperatures from −20° to +180° F. Write us for technical bulletins D1353 and D1346. They're FREE! Inquiries on your ball valve needs are welcome.

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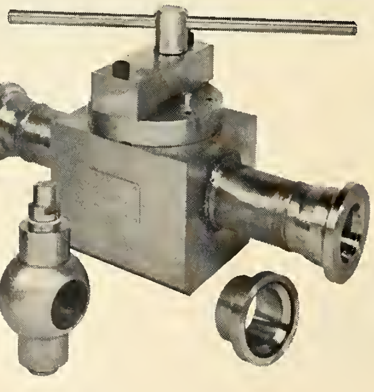

Circle No. 42 on Subscriber Service Card

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American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005 fully proportional solid-state controller. Three voltage ranges are provided—0 to 20, 0 to 200, and 0 to 2,000v—to accommodate all detector types. D-c voltages are regulated to 10 ppm for line voltage variations from 75 to 135v.

Circle No. 163 on Subscriber Service Card

Precision Calibrator

Probescope Co., Inc., has introduced a precision calibrator that, combined with a spectrum analyzer, gives visual display of each of the IRIG channels at three sideband check points —upper, center, and lower.

Model TCC-1 performs this automatic sideband sequencing for IRIG channels 1 through 18 plus A through E.

The unit controls the center frequency, sweep width, resolution and gain of the analyzer in the CAL position. Calibrator accuracy is rated at 0.01% of frequency. Stability of the display is a direct function of the analyzer's oscillator, which has a maximum drift frequency rate of ±30 cps over a 24-hour period.

Both the calibrator and the analyzer can be used separately. The analyzer is a log-lin scanning heterodyne unit for visual monitoring of all channels in the 350 cps to 120 kc range.

Circle No. 164 on Subscriber Service Card

X-Y Recorder

A compact solid-state X-Y recorder which offers a sensitivity of 100 microvolts per inch has been announced by Varian Associates.

The Model F-60 features a constant 1-megohm input impedance, accuracy of 0.1% full scale, a floating and guarded input, and a vacuum system that permits positioning, load, or removal of paper while the system is in operation.

The recorder uses a cartridge-type pen and enclosed feedback potentiometers. Common mode rejection is over 150 db. Transverse exceeds 60 db. The time sweep provides 8 ranges from 0.5 to 100 seconds per inch at an accuracy of 2%.

Circle No. 165 on Subscriber Service Card

Opto-electronic Isolator

An optoelectronic coupling device which permits economical high-voltage electrical isolation up to 5,000v has been introduced by Texas Instruments Inc.

The Model TIXL101 optical isolator combines a planar-silicon light sensor with a gallium-arsenide light source in a single opaque epoxy package.

The unit is capable of flat response beyond 10 kHz, with a typical reverse switching time of 1.5 microsecs and a forward switching time of 15 microsecs.

Input current rating is 50 milliamps. Output is 250 microamps minimum. The device provides stable performance over a temperature range from —55° to 125°C.

Circle No. 166 on Subscriber Service Card

Scanning Calorimeter

A differential scanning calorimeter with full-scale sensitivity of one millicalorie per second has been announced by Perkin-Elmer Corp.

Model DSC-1B directly measures heat capacity and transition energies from which such data as crystallinity, thermal history effects, reaction rates, thermal stability, and purity can be obtained.

Standard equipment includes a transparent sample holder cover with side-access ports and a base heater.

Circle No. 167 on Subscriber Service Card

Laser Focuscope

A laser focuscope designed to aid in focusing the laser beam on target has been introduced by Maser Optics, Inc.

Model 364 incorporates a reflex optical system, a set of apertures 1, 2, 5, 10 and 15-mm in diameter to control entrance beam size, an adjustable field iris for optimizing the image intensity, and a cross-line reticle for positioning the point of impact precisely on target.

The focuscope is an in-beam instrument, permitting observation of the target immediately after firing. A trapdoor mirror in one position couples the eyepiece to the objective lens. In its other position, it allows the beam to pass unrestricted through the housing.

Standard equipment includes three eyepieces, and one air-spaced acromatic objective lens of 100-mm focal length.

Circle No. 168 on Subscriber Service Card

Reconnaissance System

Development of a rapid access color reconnaissance system which uses black-and-white film has been announced by Fairchild Space & Defense Systems.

The spectral zonal reconnaissance system simultaneously furnishes aerial photography in color, black-and-white and camouflage detection modes by dividing terrain-reflected light into several intervals in the near-ultraviolet,

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visible and near-infrared spectrum.

The single panoramic camera is equipped with four rotating lenses of three-inch focal length which record images of the same target through filters of different wavelengths side by side on 9½-in. infrared roll film. The blue, green, red and near-infrared filters employed produce black-and-white photos with densities proportional to the brightness of the particular interval of filtered light.

Positive transparencies are produced from the negative film. By inserting these in a specially-designed spectral zonal viewer equipped with four projection lenses, any combination of images can be superimposed on the screen through a selection of colored filters.

Circle No. 169 on Subscriber Service Card

new literature

LOGIC HANDBOOK—A 352-page logic handbook is available upon request from Digital Equipment Corp. The book contains application notes, specifications and price information for more than 150 modules, notes on analog-to-digital conversion theory and techniques, and several experiments.

Circle No. 170 on Subscriber Service Card

PYROFUZE DATA—A complete information package on the forms, compositions and applications of Pyrofuze is now available from Pyrofuze Corp., affiliate of Sigmund Cohn Corp. The package includes engineering data on the application of Pyrofuze to separation and release devices, bridge-type initiation, and braid, foil and tubing forms. There are also discussions of cookbook methods of applying Pyrofuze to systems from programmed rocket motors to one-shot electrical switching.

Circle No. 171 on Subscriber Service Card

WELDING SYSTEMS—A brochure describing programmed inert gas multi-electrode (PIGME) welding systems is offered free of charge by Thomson Electric Welder Co., Inc. The four-page brochure discusses in detail the concept of PIGME welding, how it works, its advantages over other welding systems, and the types of PIGME welds. It also contains a description of the applications of PIGME welding, with diagrams and photographs.

Circle No. 172 on Subscriber Service Card

FLOATED INTEGRATING GYROS—Reeves Instrument Co., division of Dynamics Corp. of America, has available a book entitled "A Handbook on Floated Integrating Gyros." The 32-page handbook provides technical information as to theory, design and operation of single-axis floated gyros and accelerometers. It describes integrating gyros in terms of internal construction, basic relevant equations, block diagrams, basic errors and other pertinent data. An in-depth study of microsyns and temperature regulation is included, together with complete details on rate gyros and linear accelerometers.

Circle No. 173 on Subscriber Service Card

METEOROLOGICAL SYSTEMS—Publication of a meteorological systems brochure is announced by Fairchild Hiller's Electronics & Information Systems Div. The six-page brochure describes two advanced state-of-the-art, lightweight, transportable systems which provide data processing capability for automatic computation and analysis of meteorological and nuclear fallout data. Included are design considerations typical to meteorological systems, with data tabulations and graphs. The illustrated brochure describes an automatic atmospheric sounding set which is a combination of a passive-angle tracking system and an active X-band radar ranging system.

Circle No. 174 on Subscriber Service Card

METAL SPINNING DATA—A data book on the state of the art of metal spinning is available free of charge from Spincraft, Inc. The 64-page publication covers the adaptability of shapes to metal spinning, cost comparison of automatic spinning versus stamping, spinning versus deep drawing and listings of metals that can be formed by the spinning process. It also contains a material thickness guide, dimensional tolerance guide and illustrations of typical metal reduction characteristics.

Circle No. 175 on Subscriber Service Card

ALUMINUM STRESS ANALYSIS—Data on allowable stresses for a number of widely used aluminum alloys are presented for the first time in Aluminum Co. of America's "Alcoa Handbook of Design Stresses for Aluminum," prepared for engineers and architects concerned with design of aluminum strength members. Arranged in three sections, the 180-page book first discusses design data and various elements—mechanical properties, buckling formula coefficients, safety factors—employed in the general formulas used to calculate allowable stresses. Part two contains 11 tables of mechanical property data and buckling constants for more than 150 aluminum alloys. The final section is an American Society of Civil Engineers report presenting specifications for allowable stresses in the structural field for alloys 6061-T6, 6062-T6, 6063-T5 and 6063-T6.

Circle No. 176 on Subscriber Service Card

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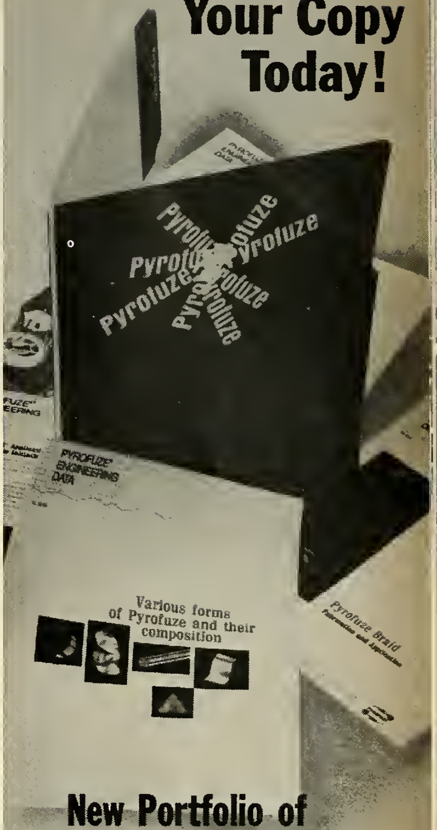
Pyrofuze
PYROFUZE ENGINEERING DATA
Various forms of Pyrofuze and their composition
Pyrofuze Braid

New Portfolio of
PYROFUZE®
Engineering Bulletins

Listed below—major brochures in our latest portfolio, available to you on request . . .

Forms of Pyrofuze (4 Pages):
Composition, mechanics and performance of specific Pyrofuze forms.

Pyrofuze Braid (4 Pages):
Discussion of braid and its application to a wide range of ignition systems.

Separation & Release Devices (6 Pages):
Use of Pyrofuze for various types of separation systems from reefing lines to large structural members.

Bridge Type Initiation (2 Pages):
Essential facts concerning squib-type initiators.

Foil and Tubing (2 Pages):
Basic data on the mechanics of foil, discs and tubing.

Pyrofuze Omnibus (6 Pages):
Suggested Pyrofuze applications from programmed rocket motors to one-shot electrical switching.

PYROFUZE Corp.

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Mount Vernon, N.Y.

AIR FORCE

$5,600,000—**Kollsman Instrument Corp.**, Elmhurst, N.Y., for support equipment for AN/USQ-28 aerial electro-photo mapping system.

$1,700,000—**Electronic Communications, Inc.**, St. Petersburg, Fla., for production of modification kits to increase the capability of the AN/TRC-66 combat communication systems.

$1,600,000—**International Telephone and Telegraph Corp.**, ITT Federal Labs, Nutley, N.J., letter contract for LORAN-C navigation receivers for C-141A Starlifter jet aircraft.

$1,238,865—**General Motors Corp.**, AC Spark Plug Div., Milwaukee, Wisc., increment to existing contract for R&D for the *Titan II* inertial guidance system.

$1,050,000—**Hughes Aircraft Co.**, Fullerton, Calif., for study and design specifications for the Tactical Air Control Centers.

$78,553—**Ewen Knight Corp.**, East Natick, Mass., for design, development and fabrication of a dual-frequency radiometric system.

$64,800—**Block Engineering, Inc.**, Cambridge, Mass., for research directed toward the study of molecular properties using absorption and index of refraction techniques.

$49,941—**Raytheon Co.**, Research Div., Waltham, Mass., for investigation of mode-locking mechanisms in lasers and their implications.

$34,292—**Lockheed Missiles and Space Co.**, Palo Alto, Calif., for investigation of energy-band structure of semiconductors.

ARMY

$4,507,000—**Raytheon Co.**, Lexington, Mass., modification to existing contract for design and development of the *Hawk* anti-tactical ballistic missile/*Hawk* improvement program. Also, $1,872,138 letter contract for engineering services for the self-propelled *Hawk* system.

$4,400,000—**Lear Siegler, Inc.**, Anaheim, Calif., first-year increment to $7,400,000 contract for two-year buy of classified electronics equipment.

$1,151,738—**FMC Corp.**, San Jose, Calif., cost-plus-fixed-fee contract for advanced production engineering for *Hawk* launchers.

$717,450—**General Dynamics Corp.**, Pomona, Calif., for additional FY 1966 engineering services for *Redeye* weapon system.

$485,000—**McDonnell Aircraft Corp.**, St. Louis, Mo., for engineering development for *Medium Assault Weapon* missile system.

$399,714—**Raytheon Co.**, Andover, Mass., for repair parts for *Hawk* missile system. Also $168,870 for repair work for the *Hawk* missile system.

$318,844—**American Optical Co.**, Southbridge, Mass., for high-energy laser research.

$231,600—**Hughes Aircraft Co.**, Los Angeles, for overhaul/repair of *Nike-Hercules* backward-wave oscillators.

NAVY

$34,550,000—**General Dynamics Corp.**, Pomona, Calif., for work on *Terrier* and *Tartar* air defense missiles.

$11,561,802—**Kentron Hawaii, Ltd.**, Honolulu, Hawaii, in three-year negotiated-cost contract for operation and maintenance of telemetry installation in Pacific Ocean.

$3,115,251—**General Precision, Inc.**, Little Falls, N.J., for navigation computer sets.

$2,838,803—**Hughes Aircraft Co.**, Fullerton, Calif., for shipboard radar equipment.

$2,650,000—**Raytheon Co.**, Oxnard, Calif., for development models of fire-control systems for basic-point-defense surface missile system program.

$1,221,000—**Head Construction Co.**, Washington, D.C., for construction of an addition to the Autodin facility at Andrews AFB, Md.

$1,130,075—**Sperry Rand Corp.**, Univac Div., St. Paul, Minn., for programming of computers at the Naval Air Development Center, Johnsville, Pa.

$1,104,000—**North American Aviation, Inc.**, Anaheim, Calif., for repairs to certain models of ship inertial navigation system gyroscopes.

$1,000,000—**Bendix Corp.**, Pacific Div., North Hollywood, Calif., for advanced acoustic ship positioning systems.

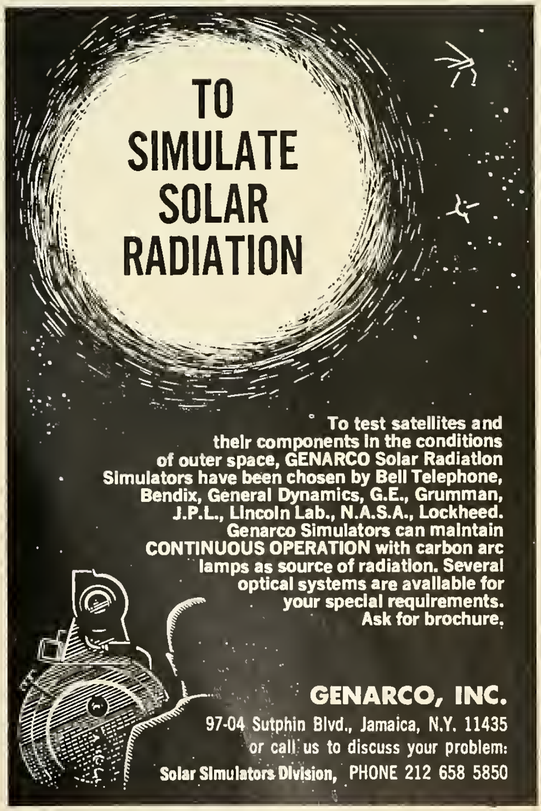
$555,519—**Harvey Aluminum, Inc.**, Torrance, Calif., increment to a $7,829,937 fixed-price contract for 20-millimeter projectiles.

$449,975—**Honeywell, Inc.**, Ordnance Div., Seattle, Wash., for engineering, drafting, computer and necessary supporting services, facilities and materials in connection with torpedo Mk 48 instrumentation, suspended trainable unit and oceanographic/hydroacoustic test programs.

$73,885—**Northrop Corp.**, Norair Div., Hawthorne, Calif., for hydra techniques launching vehicles study.

NASA

$1,529,460—Awarded 21 supplementary or new research grants and contracts to 12 universities, colleges and private institutions: $72,856—**Polytechnic Institute of Brooklyn**, Brooklyn, N.Y., for theoretical and experimental electronic properties of thin films; $15,000—**Stevens Institute of Technology**, Hoboken, N.J., for proximity effects between superconducting and normal metals; $67,387—**University of Connecticut**, Storrs, Conn., for an experimental and analytical study of the heat-transfer and flow mechanics of high-velocity condensing vapors; $35,199—**Louisiana State University**, Baton Rouge, La., for research and evaluation of the energy transfer in the char zone during ablation; $39,935—**University of Texas**, Austin, Tex., for research on propagation and dispersion of hydromagnetic and ion cyclotron waves in plasmas immersed in magnetic fields; $34,591—**Graduate Research Center of the Southwest**, Dallas, for research and an extension in the period of performance of a contract for design and construction of five ionospheric probes in each of three *Nike-Apache* rocket payloads; $132,135—**Graduate Research Center of the Southwest**, Dallas, for investigation into the mechanism and rates of atmospheric mixing in the lower thermosphere; $59,331—**Graduate Research Center of the Southwest**, Dallas, for study of electron collision frequency under ionospheric conditions; $64,568—**University of California**, San Diego, La Jolla, Calif., for additional research and an extension in the period of performance of a contract for the purpose of conducting analytical, theoretical and experimental studies of geomagnetically trapped particles; $14,953—**University of California**, Riverside, Calif., for atomic scattering theory study; $30,000—**University of California**, Berkeley, Calif., for optimization of design of space experiment from the standpoint of data processing; $7,000—**University of Southern California**, Los Angeles, for investigation of bio-electrodes; $70,300—**Stanford University**, Stanford, Calif., for electron content distribution and temporal variation in the ionosphere by means of scintillation and Faraday rotation of satellite radio transmissions, including consideration latitudinal effects of magnetic storms; $300,000—**Stanford University**, Stanford, Calif., for theoretical and experimental radio and radar studies of lunar and planetary ionospheres, atmospheres, and surfaces, the Sun and the interplanetary medium; $62,700—**Stanford University**, Stanford, Calif., for a theoretical and analytical study of telemetry occultation data available from the *Mariner* program; $70,000—**Stanford University**, Stanford, Calif., for gravitational and resonance experiments on very-low-energy free electrons and positrons. Also, $199,000 for field infrared analysis of terrain surfaces; $35,000—**Oklahoma State University**, Stillwater, Okla., for analytical and limited experimental study of the mechanisms of impact, penetration and light emission of micrometeorites on an aluminum-coated photomultiplier; $96,895—**Colorado Seminary**, Denver, Colo., for analysis of the NASA technology utilization program and external communication network of commercial industry; $18,970—**Ohio State University**, Columbus, Ohio, for theoretical and experimental investigation of the measurement of angular rotation with photons; $32,640—**Indiana University**, Bloomington, Ind., for research of an experimental investigation of the neurological correlates of information reception.



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496,890—**Battelle Memorial Institute,** Columbus, Ohio, from Headquarters for planning research in the area of launch vehicle and propulsion program.

$426,188—**Bendix Corp.,** Pioneer Center, Davenport, Iowa, from Manned Spacecraft Center for evaluation and design of cryogenic pressure vessels.

$266,109—**Space Ordnance Systems,** El Segundo, Calif., from Manned Spacecraft Center for design, development and qualifying a single bridge-wire initiator.

$259,700—**Dunlap and Associates,** Darien, Conn., from Headquarters for development of display techniques for *Apollo/Saturn* checkout systems.

$259,471—**Stanford University,** Stanford, Calif., from Manned Spacecraft Center for active seismic experiment for ALSEP.

$236,500—**Rocket Research Corp.,** Seattle, Wash., from Manned Spacecraft Center for hydrazine jet gun thrust chamber assembly.

$232,797—**Varian Associates,** Beverly, Mass., from Headquarters for research leading to development of an atomic hydrogen maser for space vehicle application.

$200,000—**AiResearch Manufacturing Co.,** Los Angeles, from Marshall Space Flight Center for early lunar shelter design and comparison study.

$111,885—**Planning Research Corp.,** Los Angeles, contract modification from Headquarters for two-phase reliability study of the *Geos* spacecraft.

$111,843—**Bunker-Ramo Corp.,** New York City, from Headquarters for design of an automated program management and information system for research and technology efforts in the national aeronautical and space program.

$99,351—**Smith, Hinchmean & Grylls Associates,** Detroit, Mich., from Manned Spacecraft Center for finalized design criteria for lunar sample reviewing laboratory.

$95,983—**Lockheed Aircraft Corp.,** Lockheed Propulsion Co., Redlands, Calif., from Western Operations Office for study of fluid-controlled solid-propellant rocket motors.

$89,765—**Philco Corp.,** Palo Alto., Calif., from Marshall Space Flight Center for R&D study to establish basic sensor requirements for an advanced spaceborne detection tracking and navigation system capable of performing interplanetary missions.

$80,000—**Dudley Observatory,** Albany, N.Y., from Manned Spacecraft Center for *Gemini* micrometeoroid collection experiment S-10.

$69,522—**Kaman Aircraft Corp.,** Kaman Avidyne Div., Burlington, Mass., from Electronics Research Center for terminal landing guidance and control system requirement study.

$66,500—**Honeywell, Inc.,** Aeronautical Div., Minneapolis, from Manned Spacecraft Center for *Apollo* C/M SCS displays and electronics.

$65,500—**Philco Corp.,** Western Development Labs, Palo Alto, Calif., from Ames Research Center for study providing a system analysis of the proposed Ames lunar magnetometer experiment.

$64,000—**Avco Corp.,** Space Systems Div., Wilmington, Mass., from Langley Research Center for one-year contract to develop a system to measure the mass of a projectile when fired from an exploding foil gun.

$64,000—**Lockheed Missiles and Space Co.,** Palo Alto, Calif., from Langley Research Center for study of trace contaminants and regeneration of absorbent beds used in spacecraft atmospheric control for extended missions.

$58,000—**TRW, Inc.,** Systems Group, Redondo Beach, Calif., from Manned Spacecraft Center for unified S-band transponder.

$53,376—**Douglas Aircraft Co., Inc.,** Santa Monica, Calif., from Western Operations Office for continued study of a hybrid and advanced solid motor stage sizing for the *Scout* fourth stage.

$44,252—**Boeing Co.,** Huntsville, Ala., from Marshall Space Flight Center for Earth-orbit rendezvous guidance study.

$29,000—**TRW, Inc.,** Electrical Products Dept., Cleveland, from Manned Spacecraft Center for study of an advanced concept three-phase, 400-cycle inverter to operate with a fuel cell.

Electronic Communications, Inc., St. Petersburg, Fla., from Langley Research Center for development of an X-band, 8.45-gigahertz telemetry transmitter. Amount not disclosed.

INDUSTRY

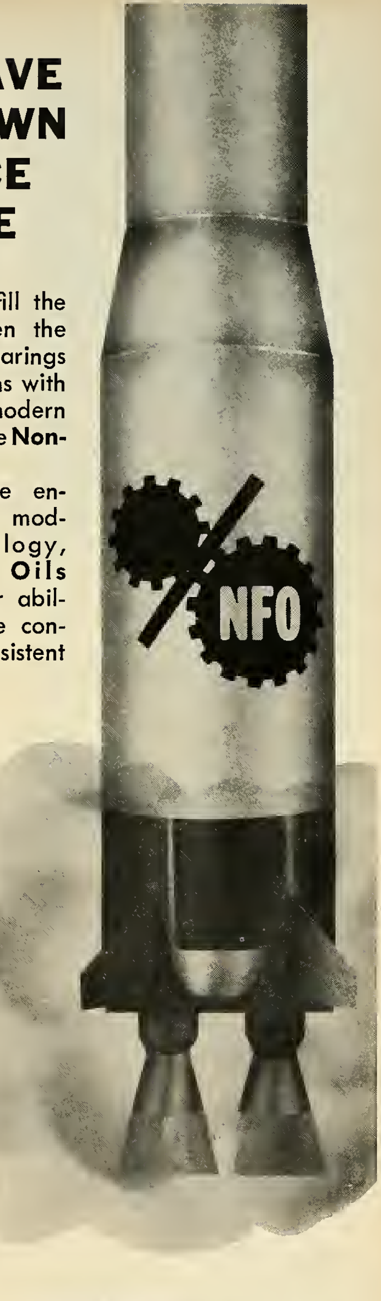
$400,000—**Varian Associates,** Palo Alto Tube Div., Palo Alto, Calif., from **Alfred Electronics,** Palo Alto, Calif., for magnetically shielded backward wave oscillators.

$307,179—**United Aircraft Corp.,** Hamilton Standard Div., Windsor Locks, Conn., from **Martin Co.,** Orlando, Fla., for ram airturbines for the *Walleye* air-to-surface weapon program.

$209,698—**American Electronics, Inc.,** Fullerton, Calif., from **Martin Co.,** Orlando, Fla., for gyro motors, gear reduction motors, torque assemblies, signal generators, and caging assemblies for the *Walleye* air-to-surface weapon program.

$100,000—**General Electronic Labs, Inc.,** Nashua, N.H., from **Electronic Specialty Co.,** Los Angeles, for a quantity of telemetry data receivers and dual channel AM tracking receivers.

$55,000—**Stellarmetrics, Inc.,** Santa Barbara, Calif., from **Douglas Aircraft Co., Inc.,** Santa Monica, Calif., in two contracts for solid-state multicoders for aerospace telemetry.



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names in the news

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Robert B. Wyland: Elected a vice president of the Marquardt Corp. He will serve as vice president of administration with responsibilities for certain staff activities and the acquisition program.

H. O. Davis: Named director of the equipment and facilities engineering branch of the Houston Aerospace Systems Div., Lockheed Electronics Co. He will assist in directing more than 1,000 engineers and technicians who are supporting NASA's space programs at the Manned Spacecraft Center.

Robert A. Gollhardt: Named executive vice president and general manager of the Instrument Div. of Lear Siegler, Inc. **Ronald V. Paolucci** was named vice president and assistant general manager of the division.

John T. Sokel: Joined the MITRE Corp. as controller. He was formerly operation controller of the Microwave and Power Tube Div. at Raytheon Co.

Ansel D. Greenway: Named assistant treasurer of Fulton Industries, Inc. He has been with the company since 1955.

Dr. A. James Boness: Joined the Center for Naval Analyses of the Franklin Institute. He has been assigned to the Naval Warfare Analysis group.

Maj. Gen. John T. Honeycutt: Named commander of the Defense Atomic Support Agency's Field Command, Sandia Base, Albuquerque, N.M., and deputy director, DASA.

John W. Haanstra: Joined International Business Machines Corp.'s Federal Systems Div. as vice president and general manager of the Federal Systems Center.

Thomas G. Faria: Awarded a patent for an electric tachometer with inductive discharge means. He is president of the Thomas G. Faria Corp. Features of the basic patented invention allow superior tachometer accuracy free from oscillatory waves.

Kristo A. Gregory: Joined LFE Electronics, a division of Laboratory for Electronics, Inc., as a senior electronics engineer. He will do systems analysis work on the firm's navigation systems.

Dr. Vincent S. Haneman, Jr.: Named director of the office of engineering research at Oklahoma State University. He is president of Haneman Associates, Inc., an engineering consulting firm.

Ralph R. Ragan: Appointed deputy director of the instrumentation laboratory, Massachusetts Institute of Technology. He will be responsible for the administration of programs being carried out for NASA.

N. J. Dann: Appointed assistant to the president of Holley Carburetor Co. He has been with the company for 24 years. Prior to this appointment, he was general manager of the Marine Products Div.

Robert P. Azinger: Named administrative assistant to the division president at Pratt & Whitney Aircraft, a division of United Aircraft Corp.

Dr. C. Kumar N. Patel: Received the Optical Society of America's Adolph Lomb Medal. He will be the 14th recipient of the award. Among his contributions is participation in the discovery of more than 200 laser transitions encompassing approximately 12 different gas compositions.

Dr. Van W. Bearinger: Appointed vice president and general manager of Honeywell, Inc.'s military and space-oriented systems and research division. He will direct nearly 600 scientists, engineers and technicians engaged in applied research, advanced technology and advanced weapons systems to meet future defense and space needs.

Frank H. Scott: Elected a vice president of Midland-Ross Corp. He will continue to be in charge of the Janitrol Aero Div.

William P. Cole: Elected to a one-year term as a director-at-large of the Society of Plastics Industry, Inc. He is president and chief executive officer of the Polymer Corp.

Dr. Eugene C. Huebschman: Appointed professor of electrical engineering at the University of Tennessee Space Institute. He was formerly staff scientist for Pan American Airways Guided Missiles Range Div.

Robert A. Hollingshead: Joined the staff of the Center for Naval Analyses of the Franklin Institute. He was previously a digital computer programmer with the Defense Communications Agency.

Frank A. Zawada: Granted a patent on an invention covering a propagating structure for high-power microwave tubes. He is an engineering section head at Raytheon Co.'s Microwave and Power Tube Div.

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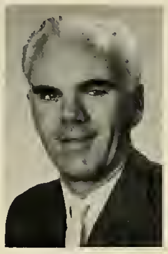

RAUCH

Douglas M. Coombs: Elected vice president and secretary of Simmonds Precision Products, Inc. The company is a manufacturer of measurement, display and control systems for space, defense and industry.

Bernard Mayer: Named director of instrumentation marketing of the Industrial Technology Div. of Lockheed Electronics Co.

James V. Bitner: Named president of the Astronics Div. of Lear Siegler, Inc. In addition to his new responsibility, he will continue to serve as president of the company's Instrument Div.

Dr. Stanley E. Rauch: Named assistant to the director of the Johns Hopkins University Applied Physics Laboratory. He will be responsible for planning and coordinating research and development in guidance, control, radar, microelectronics and microwaves.

Francis L. Hall: Appointed president of Micro-Radionics, Inc. He has been vice president and general manager of the firm.

Thomas A. Brendle: Elected president of Audn Corp. The firm will do contract R&D work on systems and controls required for industrial processing and production.

J. Tyler Nourse: Named staff vice president for Electronic Industries Assn.'s parts division. He functioned as staff director of the division, which serves manufacturers of electronic parts, for 12 years. He remains staff director of the distributor products division.

William B. McKnight: Granted a one-year research and study fellowship at Oxford University, England, by the Secretary of the Army. The program began in 1955 and has provided the opportunity for long-term research and study to over 100 outstanding scientists.

Clinton W. Hartman: Elected executive vice president of CTS Corp. He has been associated primarily with the development of the company's cermet resistive, conductive and insulative films.

Alex B. Owen: Appointed vice president and general manager of Clifton Precision Products, a division of Litton Industries. He will be responsible for the operations of the five Clifton plants.

Brig. Gen. Leland G. Cagwin: Named commander of the U.S. Army Test and Evaluation Command, Aberdeen Proving Ground, Md. He has also been nominated by President Johnson for promotion to major general.

Jerome I. Davis: Named president of Consolidated Diesel Electric Co., a division of Condec Corp. He is also a vice president of Condec and was previously vice president and general manager of the division.

Dr. E. M. Baldwin: Appointed vice president and general manager of Hoffman Electronic Corp.'s Semiconductor Div. He was most recently vice president of engineering at Globe-Union, Inc.

Fred C. Chandler: Named vice president and director of manufacturing operations for the California division of the National Screw & Manufacturing Co. Last year, he was elected to company's board of directors.

John B. Kelley: Elected a director and president of Economic Systems Corp., a subsidiary of Avco Corp. He is also a vice president of Avco's Defense and Industrial Products Group.

Col. Kenneth W. Schultz: Nominated by President Johnson for the temporary rank of brigadier general. He is deputy for Ballistic Missile Re-entry Systems at Norton AFB, San Bernardino, Calif.

Dr. David E. Knapp: Named chief scientist of the energy conversion laboratory at the Donald W. Douglas Laboratories, part of Douglas Aircraft Co., Inc.

Dr. Herbert L. Groginsky: Has been granted a patent on his invention of a novel resolution improvement device used with sonar and radar systems. He is manager of the analytic techniques department of the advanced development laboratory at Raytheon Co.'s surface radar and navigation operation.

Col. Marion B. Gibson: Named director of the communication satellite system program office at Air Force Systems Command's Space Systems Div. The office is responsible for development, procurement and launch of all spaceborne elements of military communication satellite programs.

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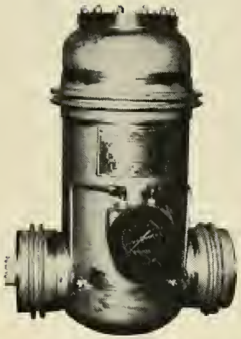

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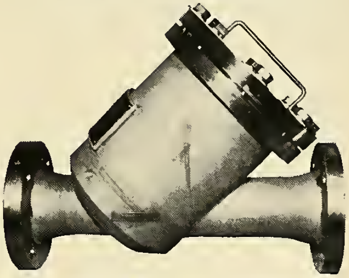

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MARCH

Human Factors & Bioengineering Conference, sponsored by the American Society of Mechanical Engineers, International Inn, Washington, D.C., March 28-29.

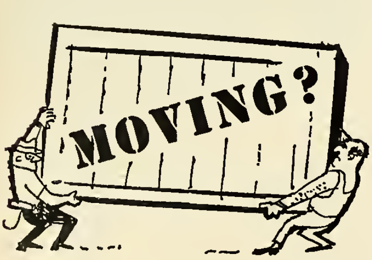
Stepping Stones To Mars Meeting, sponsored by the American Institute of Aeronautics and Astronautics, American Astronautical Society, Baltimore, March 28-30.

Sixth National Conference in Applied Meteorology, sponsored by the American Meteorological Society, American Institute of Aeronautics & Astronautics, Los Angeles, March 29-31.

Seventh Symposium on Engineering Aspects of Magnetohydrodynamics, sponsored by the American Society of Mechanical Engineers, Institute of Electrical and Electronics Engineers, American Institute of Aeronautics and Astronautics, and Princeton University, Princeton University, Princeton, N.J., March 30-April 1.

APRIL

Rubber & Plastics Industries Conference, sponsored by the Institute of Electrical and Electronics Engineers, Sheraton-Mayflower Hotel, Akron, Ohio, April 4-5.



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Conference on Exobiology, sponsored by the National Aeronautics and Space Administration and University of California Extension, Ames Research Center, Moffett Field, Calif., April 4-6.

Eighth Annual Symposium on Electron & Laser Beam Technology, sponsored by the University of Michigan, the Institute of Electrical and Electronics Engineers, University of Michigan, Ann Arbor, Mich., April 6-8.

Joint Meetings Aerospace Research Applications Center and the Indiana Executive Program, Indiana University, Bloomington, Ind., April 8-9.

Institute of Electrical and Electronics Engineers Region III Meeting, Atlanta, Ga., April 10-13.

Conference on Ground-Based Aeronomic Studies of the Lower Ionosphere, sponsored by the Air Force Cambridge Research Laboratories, Canadian Defense Research Telecommunications Establishment, Ottawa, Ontario, April 11-15.

Symposium on Generalized Networks, sponsored by the Polytechnic Institute of Brooklyn, Hotel Commodore, New York City, April 12-14.

Fourth International Quantum Electronics Conference, sponsored by the American Institute of Physics, the Institute of Electrical and Electronics Engineers, Town House, Phoenix, Ariz., April 12-15.

Fourth Symposium on Remote Sensing of the Environment, sponsored by the Air Force Cambridge Research Labs, Office of Naval Research, University of Michigan, Ann Arbor, Mich., April 12-14.

Annual Technical Meeting and Equipment Exposition, sponsored by the Institute of Environmental Sciences, El Cortez Hotel, San Diego, Calif., April 13-15.

Second International Conference on Electron and Ion Beam Science and Technology, sponsored by the Electrochemical Society and Institute of Metals Div., Park Sheraton Hotel, New York City, April 17-20.

Annual Engineering Conference and Tool Exposition, sponsored by the American Society of Tool & Manufacturing Engineers, Statler and Sheraton-Cadillac Hotels, Detroit, Mich., April 18-22.

National Association of Corrosion Engineers 22nd Annual Conference and Corrosion Show, Fontainebleau, Miami, Fla., April 18-22.

Metals Engineering Conference, sponsored by the American Society of Mechanical Engineers, Sheraton-Cleveland, Cleveland, April 18-22.

37th Annual Scientific Meeting of the Aerospace Medical Association, Dunes Hotel, Las Vegas, Nevada, April 18-21.

Seventh Structures and Materials Conference, sponsored by the American Institute of Aeronautics and Astronautics, American Society of Mechanical Engineers, Cocoa Beach, Fla., April 18-20.

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The Lessons of Vietnam — Part I

SAIGON

THE MASSIVE INJECTION of new American troops, tactics and technology into Vietnam is beginning perceptibly to turn the tide of war here in favor of the U.S.

A major share of the credit for this must go to the most professional U.S. fighting force ever sent into battle. Under difficult environmental and political restrictions, the military services are learning how to seek out and destroy an elusive guerrilla enemy on his home ground in an area where many said the U.S. should not and could not fight.

Having said this, however, it must be pointed out that the war in Vietnam has exposed major weaknesses in the research and development planning of the Dept. of Defense. It is all too apparent that success is coming in many cases despite the hardware on hand, not because of it.

This generalization, like all others, has substantial exceptions. Overall, nevertheless, the potential of U.S. advanced technology in meeting the combat problems of limited war has been shamefully neglected.

It can be said that there are many new projects in the research and development mill to meet these problems. But projects in the mill are of no help to troops in the stream of combat.

We have said for several years that elaborate and lengthy DOD development procedures intended to prove that something could be done before attempting to do it were not only discouraging industry initiative but leaving the nation short of advanced hardware. The Vietnam war is proof of just that. We may be preparing well to fight a limited war five years from now; we are not well prepared, from a hardware standpoint, to fight the one today.

One need look only at aging A-1E Skyraiders and C-47's on the runways of Tan Son Nhut, at helicopters in An Khe jury-rigged with inadequate weapon systems, at overloaded Cessna O-1E forward air-control aircraft straining to get airborne at Da Nang, at unnecessarily vulnerable boats on river and coastal patrol, at overburdened military power-generation facilities throughout the country, and at losses to anti-aircraft fire of planes tail-chasing an air-to-surface missile into target, to realize the results of that lack of preparation. This is not to say that a magnificent job is not being done with the equipment on hand. It is.

But the failure to provide the optimum equipment possible is a shameful black mark on the record of the Dept. of Defense. The COIN counterinsurgency aircraft could have been in the field by now; the Advanced Aerial Fire Support System could have been substantially moved forward; so could many other pieces of hardware needed to fight this war. In fact, only under the strongest protest from the Army has the Dept. of Defense reversed itself to permit procurement of the badly needed Bell Huey Cobra until AAFSS is ready for combat.

Dr. John S. Foster, director of Defense Research and Engineering, in testifying on Vietnam, recently told Congress:

"With the entry of major U.S. combat forces there, we have turned our attention to providing rapidly to our troops those things in the R&D program that are urgently needed and can be of immediate use."

We suggest that the time for turning such attention is long past due. Dr. Foster, who has been in office only a few months, cannot be held responsible.

But if Secretary of Defense Robert S. McNamara, in his role as commander (through the Joint Chiefs of Staff) of the Unified and Specified Commands is to receive credit for the splendid performance of well-motivated, well-trained and well-led forces in Vietnam, then he should also receive the blame for failure to provide the equipment they could have.

If this were said just with the hindsight of a visit to the combat zone, we might perhaps be more lenient. But it has been clear for some time where the course of events was leading.

In the annual DOD issue of MISSILES AND ROCKETS in March, 1963, a top defense industry official charged that the policy of directing research at just a few large weapon systems was causing neglect of other technological areas. He said: "We don't have any cushion to protect ourselves if we need to change."

In that same issue, a high military officer was quoted as saying: "We simply have not been given the responsibility of selecting those systems which we will someday be expected to use—and win with."

We said editorially in that issue of three years ago that Secretary McNamara's failure to realize the need for greater industry and military input on weapon decisions could be the Achilles heel of his Pentagon management.

SECRETARY McNAMARA in 1963 was advising the White House regarding Vietnam "that the major part of the U.S. military task can be completed by the end of 1965."

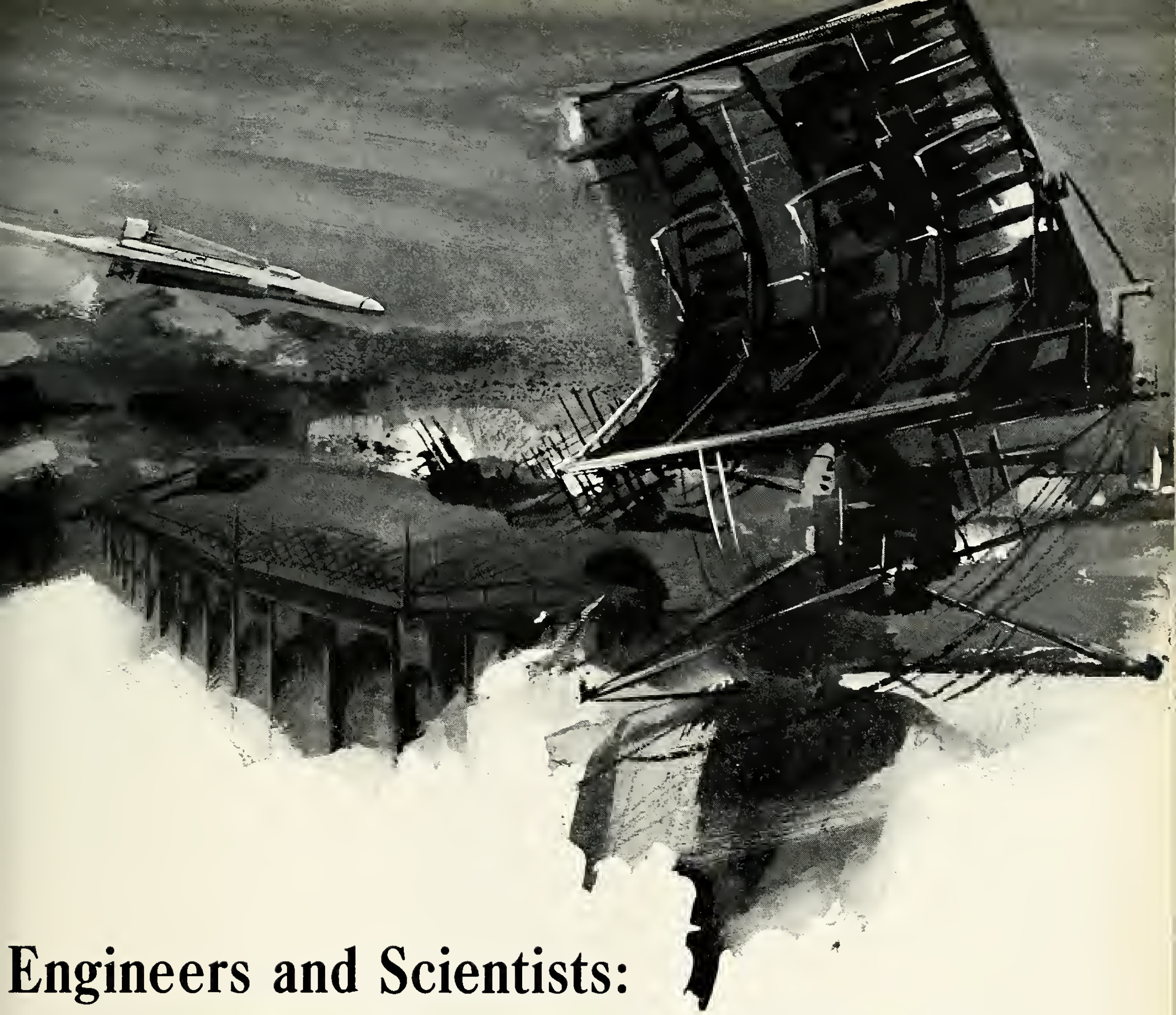
In 1964, he was telling Congress: "I personally believe this is a war the Vietnamese must fight. It is a guerrilla war that must be fought by Vietnamese countering the local Viet Cong guerrillas. I don't believe we can take on that combat task for them."

In May, 1965, he told a questioner that in the previous eight weeks there had been an improvement in the situation in Vietnam. The fact is, as the Secretary later admitted, that the Viet Cong in May and June of last year came perilously close to achieving their objective of cutting South Vietnam in half and wiping out the South Vietnamese military force—thereby winning the war.

We do not fault Mr. McNamara for not anticipating the escalation of the war undertaken by the Viet Cong and the North Vietnamese. But we do fault him for not developing the equipment to fight such a war if circumstances proved his optimistic views wrong. Such preparation is a basic tenet known to every military officer—but not, apparently, to the cost-conscious Secretary of Defense.

(First of a series.)

William J. Coughlin



Engineers and Scientists: Diversified opportunities now available on ASM's in Hughes' new Missile Systems Division

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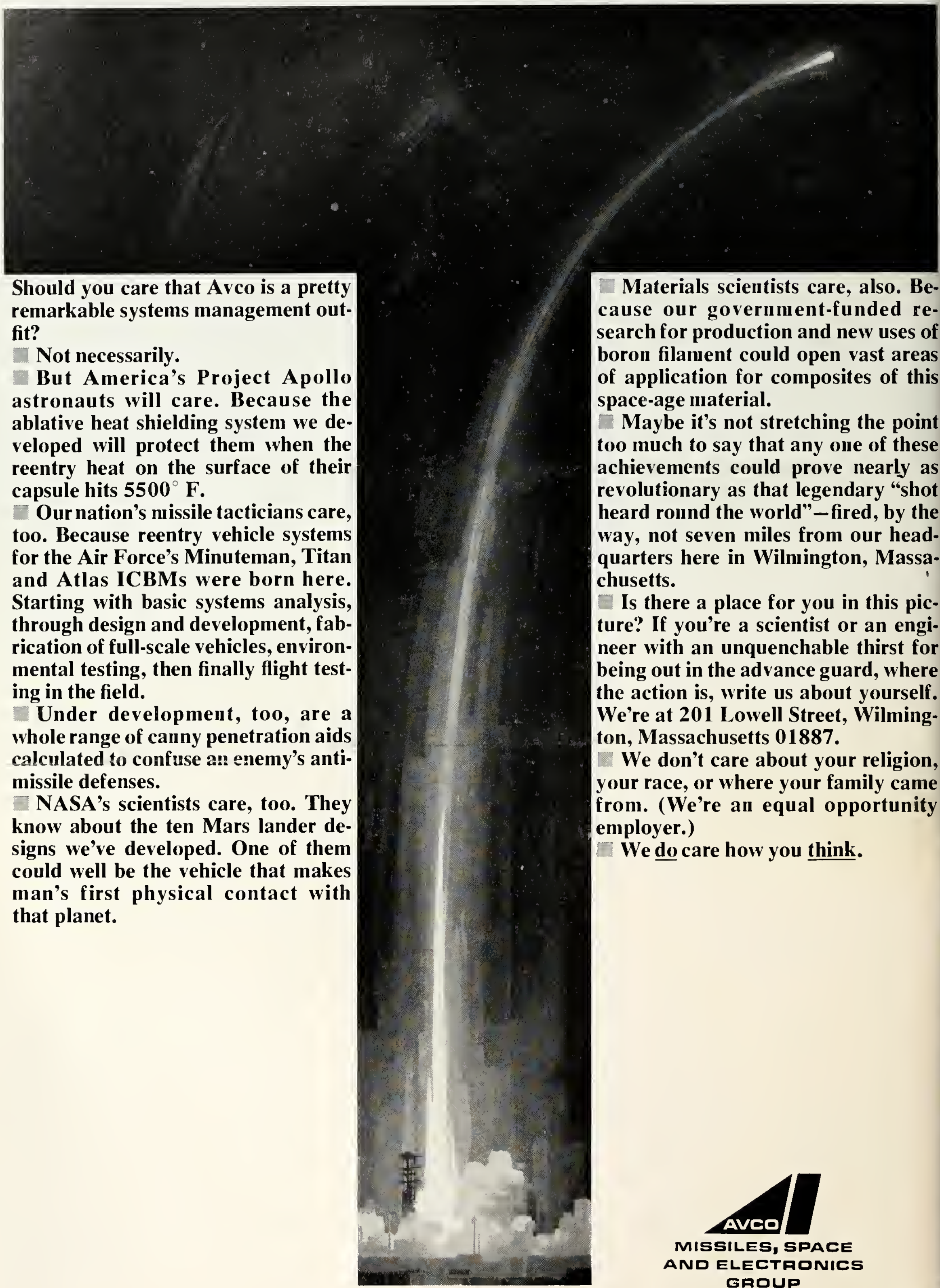

Should you care that Avco is a pretty remarkable systems management outfit?

Not necessarily.

But America's Project Apollo astronauts will care. Because the ablative heat shielding system we developed will protect them when the reentry heat on the surface of their capsule hits 5500° F.

Our nation's missile tacticians care, too. Because reentry vehicle systems for the Air Force's Minuteman, Titan and Atlas ICBMs were born here. Starting with basic systems analysis, through design and development, fabrication of full-scale vehicles, environmental testing, then finally flight testing in the field.

Under development, too, are a whole range of canny penetration aids calculated to confuse an enemy's anti-missile defenses.

NASA's scientists care, too. They know about the ten Mars lander designs we've developed. One of them could well be the vehicle that makes man's first physical contact with that planet.

Materials scientists care, also. Because our government-funded research for production and new uses of boron filament could open vast areas of application for composites of this space-age material.

Maybe it's not stretching the point too much to say that any one of these achievements could prove nearly as revolutionary as that legendary "shot heard round the world"—fired, by the way, not seven miles from our headquarters here in Wilmington, Massachusetts.

Is there a place for you in this picture? If you're a scientist or an engineer with an unquenchable thirst for being out in the advance guard, where the action is, write us about yourself. We're at 201 Lowell Street, Wilmington, Massachusetts 01887.

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APRIL 4, 1966

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Houston, Texas

gineers Adjust Army's SATCOM Antenna

Soviets Have Missile Subs On Patrol Off U.S. Coasts

Space Rescue RFP Anticipated

Mars Atmosphere Probe Debated

IEEE Panel Aids Radio Astronomy

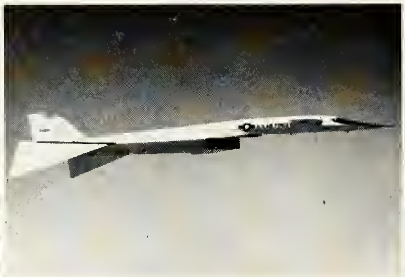
AVIATION

From here to Mars... from −392° to +212°F...

General Electric RTV silicone rubber secures Mariner's 28,224 solar cells

The job was formidable. Jet Propulsion Laboratory engineers needed a temperature-proof bonding agent to mount 28,224 solar cells in place on the four Mariner panels for its flight to Mars. JPL chose General Electric's flexible RTV-40 silicone rubber adhesive because it met design requirements: long-term resistance to environmental stresses from —392°F to 212°F. Did RTV-40 do its job? After many months in space and 21 spectacular close-ups of the Martian surface, we're inclined to say it did.

PROTECTION FROM DIRECT FLAME in fire areas is practical with silicone rubber. The jet engine oil tank shown here was coated with General Electric RTV-577 silicone rubber, exposed to a 2000°F flame for 16 minutes with no oil leakage or spillage during or after the flame exposure. Coated areas were still completely covered.



NEW TEMPERATURE-RESISTANT COATING on wings and fuselage of North American's XB-70 No. 2 contains General Electric silicone resins. The new silicone coating stays flexible at low temperatures, clings tenaciously to the substrate when the structure flexes in flight. It withstands heat too — up to 600°F at Mach 3.

WINDOW SEALS ON NASA'S APOLLO must withstand weight loss in vacuum, be non-toxic, perform uniformly in alternating hot and cold. After testing 14 high performance elastomers, North American Space Division used G-E RTV-560 silicone rubber as the sealant. RTV-560 retains high flexibility down to —160°F, meets non-flexible compression requirements down to —200°F.

For a free sample and more information about General Electric RTV silicone rubbers, greases, fluids, etc., write to us on your letterhead, describing your application. Write Section 04190, Silicone Products Department, General Electric Company, Waterford, New York 12188.

GENERAL ELECTRIC

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missiles and rockets
THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 18, Number 14 April 4, 1966

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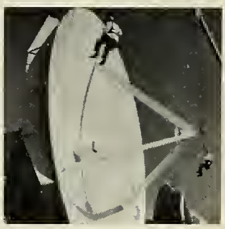
THE COVER



Engineers use bosun's chairs to make factory adjustments on 40-ft.-dia. AN/MSC-46 antenna of Mark 1B satellite communications ground-link terminal. Air-transportable terminals are being built by Hughes Aircraft Co. for Army's Satellite Communications Agency (SATCOM) (See p. 8).

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MEMO FROM THE PUBLISHER

Cape Kennedy Correspondent Voss (left) and Oceanology Editor Niblock.

What is it that makes a responsible trade journal such a valuable tool for industry? I believe it is the accuracy of its information and the experience which goes into its interpretation of events.

There is only one way to obtain this experience and accuracy. That is to hire informed, responsible editors who are fitted to their assignments with machine-tool precision. It is not easy to find such men and we search long and hard for them.

We consider ourselves fortunate in adding the pair above to our editorial staff. The gentleman seated at the left is Kurt Voss, our new bureau chief at Cape Kennedy.

We plucked Kurt out of the snows of Boston for his new assignment in sunny Florida. As a business writer for the Christian Science Monitor, he was a familiar face at the electronics companies along crowded Route 128.

But Florida is not a new beat for Kurt. He is a graduate of Florida Southern University. Formerly a technical writer with Martin-Orlando, he is familiar with the complexities of missile systems.

As a staff correspondent for the Orlando daily newspapers for more than four years, he also is at home in the busy atmosphere of the Cape. In addition to providing knowledgeable reporting of space and missile launchings from the Cape, Kurt also will be covering the important Florida segment of our industry.

We announced Bob Niblock's appointment as oceanology editor last month but I think you might be interested in a few more details. By coincidence, Bob also has a Boston newspaper background. He was a night re-write man on the Boston Herald while working for his master's degree at Boston University. He received his B.A. from Baldwin-Wallace. We found Bob right here in Washington, where he was working as a public information officer in the U.S. Naval Oceanographic Office.

We are interested in oceanology, of course, because so much of the work being done in the field is directly dependent on the advanced technology of this industry.

Kurt and Bob are going to be mighty busy in the days ahead—and the result will be that experienced, accurate reporting I mentioned.

PUBLISHER

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For more information, write: *Manager, Marketing, Raytheon Company, Santa Barbara, California.*

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The Countdown

WASHINGTON

Condor To Be $100-Million Program

Award of the development and production contract for Navy's new *Condor* long-range electro-optically guided air-to-surface missile was due late last week. Northrop's Norair Div. and North American Aviation's Columbus Div. were involved in a down-to-the-wire competition. Program is expected to be worth about $100 million, with the first year's increment pegged at about $30-35 million.

Navy To Get Advanced ASROC

New rocket-boosted ASW ballistic missile referred to by Secretary McNamara in the recent defense posture statement (M/R, Feb. 28, p. 16) is, in fact, an extended-range version of *ASROC*. The additional range will be substantial, say Navy sources, providing a better match for new fleet sonars. Prime contractor on *ASROC*, Honeywell, Inc., also will serve as prime on the new version. Navy officials say new competition will be introduced in some hardware areas, however.

Gemini Tether Lengthened

Astronaut Eugene A. Cernan, right seat pilot on the upcoming *Gemini 9* mission, will evaluate the Ling-Temco-Vought Astronaut Manuevering Unit at a distance of 125 ft. from the spacecraft. The tether has been extended an additional 25 ft. over the planned tether length on *Gemini 8*. *Gemini 9* is scheduled for mid-May.

DOD Declines Comment on Soviet A-ICBM

Top U.S. defense officials refuse to comment on reports from Moscow that large new structures, believed to house anti-ICBM missile radars, now dot the countryside around Moscow and Leningrad. Officials say the subject is so highly sensitive that any discussion of the veracity of the reports could be misleading.

Air Force Takes New Look at IR Homing

Air Force interest in use of infrared homing systems for new air-to-surface missiles is increasing. State of the art is said to be now sufficiently advanced to allow application in this area. Successful development would allow improved strikes against moving targets such as truck convoys and also make possible night operations if the target location problem can be solved.

SRAM Decision Due in Summer

Selection of a single contractor for development and production of the Air Force's *Short Range Attack Missile (SRAM)* is expected by mid-summer, according to project sources. Both Martin Co. and Boeing, holders of definition stage contracts, recently turned in to the Air Force cost proposals covering the follow-on phases.

NASA Sets Second M-2 Captive Flight

NASA has decided to schedule a second captive flight of the M-2 lifting vehicle for mid-April. If it is successful, the first manned free-fall flight will be attempted the next day. Decision for a second captive flight comes as a result of only partial success of the first one. Weather held the B-52 mother ship to only 25,000 ft. of the planned 45,000-ft. altitude. First flight of the space agency's other lifting body vehicle, the HL-10, is set for mid-year.

Navy Slates New ASW Devices

New Navy ASW engineering development projects include an improved version of the Jezebel sonobuoy system and a small, active airborne sonobuoy system known as Cass. This is intended for use in final localization and target tracking just prior to weapons delivery.

Nimbus C Launch Date Set

Launch date for the *Nimbus C* weather satellite has been set for April 26 from the Western Test Range. The spacecraft was shipped from General Electric's Valley Forge plant to WTR on March 27. Meanwhile, Rep. Joseph Karth (D-Minn.) has suggested creation of an organization similar to Comsat Corp. to sell meteorological satellite weather services to local, state, federal and foreign governments.

Navy at Work on New Satellites

Navy is studying a second-generation navigation satellite concept which it says will be more cost-effective. In conjunction with the Joint Meteorological System Project Office (JMSPO), the Navy also is developing techniques for a tactical weather satellite which could be placed in synchronous orbit to provide rapid cloud cover read-out to tactical commanders.

INDUSTRY

Lockheed Proposes Conventional Polaris

Lockheed Aircraft Corp. proposal to adapt the *Polaris* missile to a new role is under study by the Navy. Sources close to the project say *Polaris* would be fitted with a conventional warhead as a weapon for use against targets in Vietnam which are heavily defended against aircraft attack (M/R, Oct. 18, p. 18; Mar. 7, p. 12). The idea has support both within the services and the Dept. of Defense. The weapon would be available for reasonably early deployment.

Martin is Second Source for Shillelagh

Martin-Orlando has been selected as second production source (M/R, Jan. 10, p. 9) for the Army's *Shillelagh* gun-launched guided missile. Initial contract is worth just over $1.5 million. Thirty-seven requests for proposals were sent out by Army Missile Command. Other finalists were Raytheon, General Dynamics/Pomona, Maxson Electronics and Sperry/Utah. Contract is for a relatively small number of missiles to be produced during the next 22 months. *Shillelagh* is currently being mass-produced by the prime contractor, Philco's Aeronutronic Div.

INTERNATIONAL

Japanese To Visit Woomera

Two Japanese space technology experts will visit Australia this month to study facilities at the Woomera missile range. The Australians have offered to make the range available for Japanese scientific rocket launches. Behind the offer is Australian concern about possible collapse of ELDO, which was expected to be a major range user.

The Missile/Space Week

Brown Pushes Manned Bombers

Air Force Secretary Harold Brown has breathed new enthusiasm into follow-on Air Force manned aircraft and weapons programs.

Brown told a meeting of the Air Force Association in Dallas March 25 that "In my opinion, we will continue to need manned bombers in our strategic forces as far ahead as any of us can see. The F-111 in its presently planned form will provide a satisfactory replacement for a portion of the current bomber force. But an even more effective bomber will be needed to replace the B-52 G-H forces in the mid-1970's if a replacement is needed, and I think it is."

Brown said that at this point in time, "there is no doubt about the technical feasibility of advanced manned bombers of all sorts of designs. The questions which have to be answered to the satisfaction of the secretary of defense are how we propose to use such a weapon system and how it fits into the missions of assured destruction and damage limitation."

Brown emphasized that the future characteristics of new manned bombers must be evaluated in terms of both general nuclear war and limited war, concluding that it is "entirely possible" studies will show "that two types of manned bombers are needed in the years ahead."

Brown also said that "we must build for the future a balanced fighter force. This should include a family of aircraft, each designed to do one mission extremely well—counter air, close support, interdiction, or reconnaissance—and one or more others creditably well." The Secretary laid special emphasis on a new fighter which would clearly give air superiority.

OAO, AC-8 Launches Scrubbed

Scheduled launches of two NASA spacecraft were postponed last week due to high winds and mechanical difficulties.

NASA's *Orbiting Astronomical Observatory (OAO)* failed March 30 for the second time in a week to get off the ground when its *Atlas* booster suddenly shut down after a normal countdown and ignition.

Space agency officials could find no immediate explanation for the abort, which came five minutes after the opening of the hour-long launch window. Detailed inspection of recorded launch information would be necessary before a reason for the failure can be found, NASA said.

It was the second scrub in three days for *OAO*. On March 28, high-shear winds at high altitudes and a pair of malfunctioning commutators kept the vehicle and its 3,000-lb. spacecraft tied to the pad.

Launch of the *Atlas-Centaur 8*, scheduled for March 29, was scrubbed due to 140-knot winds at high altitude.

The spacecraft was shut down automatically seconds before the planned launch when a second-stage umbilical signal showed a programmed disconnect had not taken place. Before the problem was checked out, the measurement of winds aloft showed the shear to be too much for the vehicle.

It was expected that new launch dates for both missions would be announced late last week.

Shots of the Week

First fully successful launch and air-snatch recovery of the *ALARR (Air-Launched, Air-Recoverable Rocket)* was made over White Sands Missile Range, N.M., March 28.

The rocket, a modified MB-1 *Genie* carrying scientific instruments in the nose cone for upper atmosphere research, was launched from an Air Force F-4C at 44,000 ft. The aircraft was flying at Mach 2 and was in a 44-degree up-angle when the *ALARR* was launched. Rocket apogee was 150,000 ft., with immediate separation of the 180-lb. nose cone. A JC-130B, operating from Edwards AFB, Calif., made a successful mid-air recovery at 5,000 ft. in the second pass at the target.

- The Air Force successfully launched the *OV1-4* and *OV1-5* scientific satellites from Vandenberg AFB, Calif., March 30. An *Atlas* booster placed the spacecraft into circular orbits.
- The Soviet *Cosmos 113* satellite, launched March 21, was reported to have returned to Earth March 29 and soft-landed near its launching point at Baikunor, Kazakh Soviet Republic.
- A two-stage weather observation rocket, the *Kappa 9M-15*, was successfully launched March 20 by scientists from Tokyo University. The solid-fueled vehicle reached an altitude of 190 mi.

RFP Out for Aircraft Satellite

Communications Satellite Corp. has asked for industry proposals on a synchronous satellite for aeronautical communications.

The RFP was issued to 54 foreign and 15 domestic companies. Proposals are due in mid-May.

The prototype system calls for launch of one satellite over the Atlantic Ocean to provide air-to-ground-to-air communications. Specifications call for a minimum of two 2-way voice channels between aircraft and Earth stations, with options for up to four circuits. Communications between aircraft and satellite would be VHF transmission; microwave circuits would be used between ground and the satellite.

The RFP, filed with the Federal Communications Commission last week, is for two spacecraft plus a prototype. The satellite would weigh about 210 lbs. in orbit and have a 3½-year lifetime.

Last month, Comsat presented an engineering proposal for an aeronautical satellite to the Federal Aviation Agency in response to an FAA request.

IDSCP Terminals Shown

First complete transportable ground terminals for the military Initial Defense Satellite Communication Program (IDSCP) were shown publicly last week by developer Hughes Aircraft Co.

Developed for the U.S. Army, the AN/MSC-46 van-installed communication terminals will see global service late this year following first launch of the orbital relay vehicles.

Hughes' Fullerton, Calif., Communication and Radar Div. is building the mobile centrals for DOD's SatCom Agency (M/R, Jan. 31, p. 63).

Designated the Mark 1B, the partially disassembled units can be reassembled and placed in operation within 48 hours after delivery, the Army said.

First units were delivered to the Army during January; on-site tests are scheduled for the terminals during the next few months. With site preparation already under way, the first station at Helemano, Hawaii, will employ two Mk 1B terminals. The complex will serve as a communications link between the island group and the U.S. mainland and also provide a relay link for western Pacific stations.

The promise of Poseidon...

A UNIQUE BULLET FOR FLEET SUBMARINES

Engineers and scientists familiar with the technological nuances that separate one ballistic missile from another, will be quick to recognize the fundamental uniqueness of Poseidon. It will be a powerful deterrent force. One that promises unmatched operational flexibility, unprecedented ability to penetrate enemy defenses, yet will be able to operate from existing fleet ballistic missile submarines. Poseidon is a long-term project urgently requiring broad new concepts in many fields – thrust vector control, nuclear physics, nuclear weapons effects, structures, metallurgy, gas dynamics, systems and operations analysis, automatic test equipment, and surface support equipment. If you would like to help turn the promise of Poseidon into reality, send your resume to Lockheed today. Write: Mr. K. R. Kiddoo, Professional Employment Manager, P.O. Box 504, Sunnyvale, California. An equal opportunity employer.

LOCKHEED
MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

Tactical Missiles: A report from General Dynamics

Evening the odds against surprise attack:

Even for those who weren't there, newsreels of World War II and the Korean War have made this scene familiar:

Troops are moving along a road or field. Suddenly, an enemy plane swoops out of the sky with machine guns and cannons blazing. Troops scatter for cover. A few fire at the disappearing plane—but in vain.

Today, the foot soldier does not have to head for cover. He has an equalizer. Now the scene would go like this:

An enemy plane is seen in the distance. An infantryman shoulders a weapon that resembles a bazooka. Through an eyepiece he sights the plane, squeezes a trigger and a missile whooshes out of the tube. Seconds later, the plane explodes.

Such a weapon is now moving into the hands of field troops. It is made by General Dynamics and called Redeye. It is a tactical guided missile designed to be used by one man.

The bullet that gets a second chance:

A bullet or shell is affected by gravity and wind, but, by and large, once fired it continues in the direction it was originally pointed.

A sharp eye, a steady arm and an accurate gun are all you need to hit a stationary target.

A moving object has to be "led"—the gunner judges where the moving object will be in a few fractions of a second and points his bullet there.

But to "lead" an airplane traveling at the speed of sound, miles high and able to change its direction in a hurry, you need a guided missile.

An effective surface-to-air weapon must be capable of fast reaction. Its warhead must be powerful enough to destroy an attacking plane. Its speed and range must be enough to reach the attacking aircraft before the plane's offensive weapons can be launched against ground troops.

But the real key is in the word *guided*.

The guided missile, like its evasive target, can be steered and sometimes steer itself. In fact, you might call a tactical guided missile a "bullet that gets a second chance."

Let's take a look at three produced by General Dynamics—Terrier, Tartar as well as Redeye—to see how some tactical missiles work. All are essentially defensive weapons.

Terrier and Tartar are supersonic, solid-fueled missiles used by the United States Navy. Both have what is known as "semi-active homing" guidance. This involves a complex of shipboard radar and computers, combined with sensing, computing and controlling devices within the missile itself.

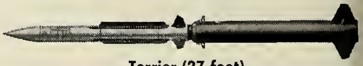
When search radar aboard a ship finds an oncoming target, a radar illumination beam, controlled through a central computer, seeks out the attacking plane. The radar waves reflected from the airplane are picked up by a sensor in the nose of the missile, which will chase its target to intercept even if the plane changes course several times.

Terrier:

Terrier is the bigger of the two. On its launcher aboard a Navy cruiser, it is about 27 feet long. The first 15 feet are the missile proper. The second 12 contain a booster rocket for propulsion.

Terrier is always ready to go. Almost within the instant that the illumination beam fastens on the approaching aircraft, Terrier is triggered.

The booster blasts the missile off the launching rack. The finder is already receiving the reflected beam from the target. Two small charges within the missile have already ignited. Their burning gases turn two small turbines. One provides power for the guidance and control systems. The other operates a hydraulic pump whose fluids move the small guidance fins on the missile's tail.

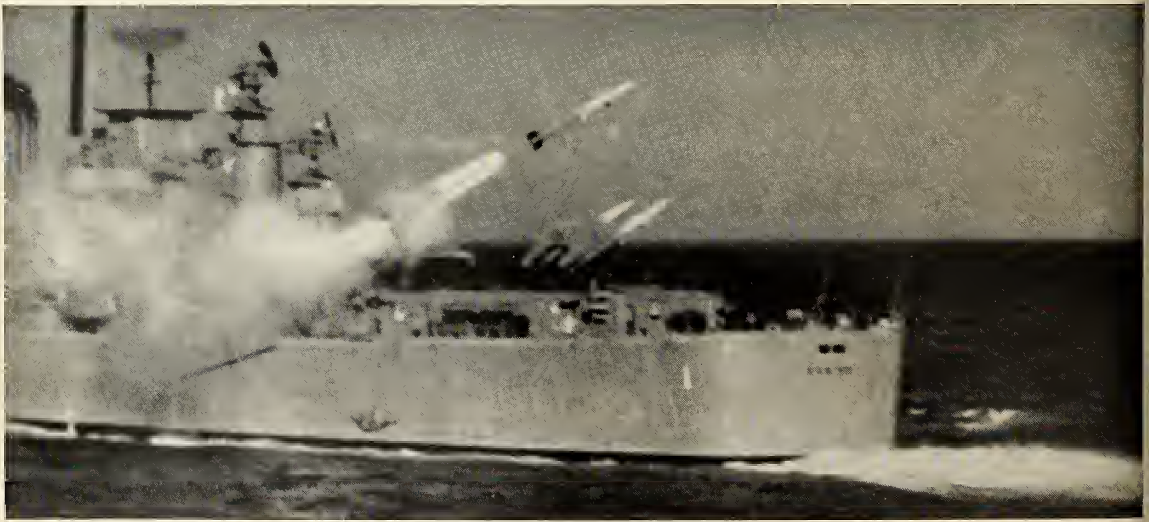

Terrier (27 feet)

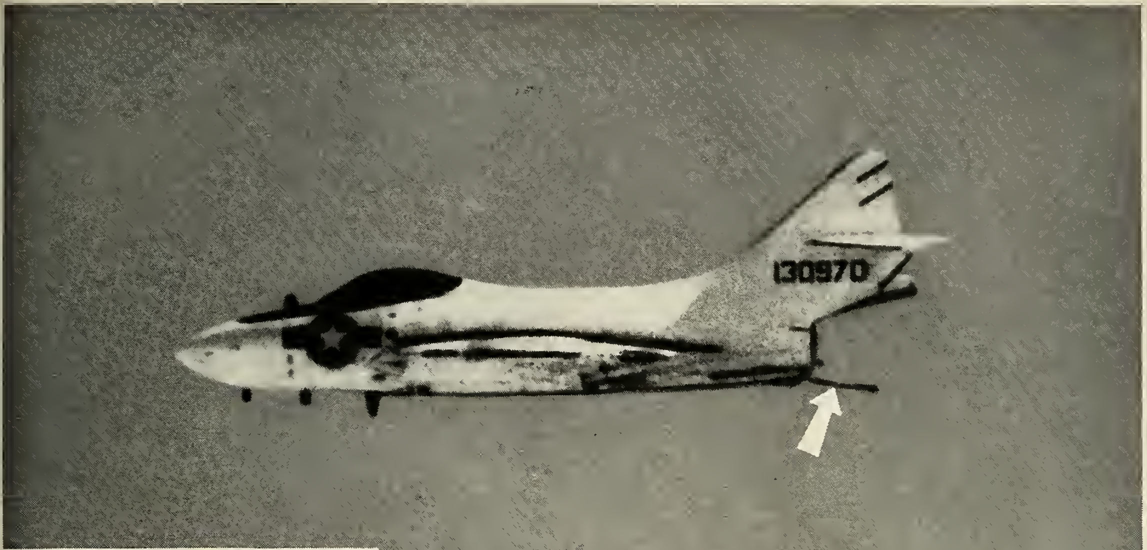
As the booster burns out and then drops away, a sustainer rocket within the missile proper commences firing to continue necessary velocity to intercept.

Tartar:

Tartar is similar to Terrier, but more compact (15 feet long and about 1,200 pounds compared to 27 feet and about 3,000 pounds for Terrier).

Its booster and sustainer are combined into a single-rocket engine. When


Above: Cruiser fires a Terrier. **Right:** Diagram shows radar waves sent from a ship and reflected from a plane being received by sensor in nose of the missile. Even if the plane takes evasive action, the missile will change course to intercept.



1. An infantryman (above) fires a Redeye missile at a target drone airplane.

2. This is an actual photo of a Redeye missile (arrow) entering the jet exhaust of a drone airplane. Immediately after this photograph was taken, the plane exploded.

Tartar gets its signal, the engine generates high initial thrust to shoot aloft, then reduces its force to provide the long sustained velocity to reach and chase a distant target.

Both Terrier and Tartar, in spite of their size, can be fired repetitively almost as fast as a bolt-operated rifle.

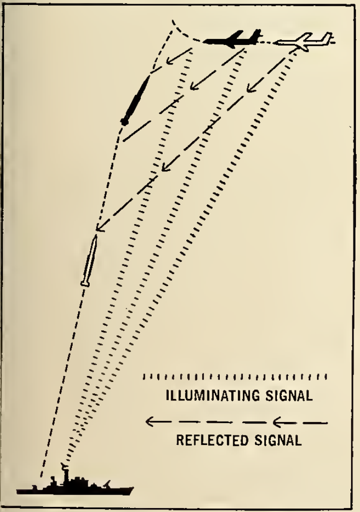
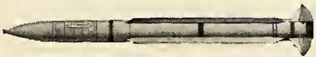


Diagram shows how missile changes course as the target changes course.

Stored in automated magazines, they can be lifted onto a launcher, hooked into the central computer radar control and fired within seconds.

Ships equipped with Terrier or Tartar can defend themselves against an armada of attacking aircraft today far more effectively than would have been possible against a single aircraft ten years ago.



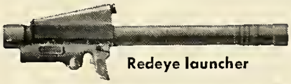
Tartar (15 feet)

Redeye:

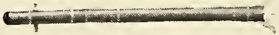
Redeye is designed to destroy low-flying aircraft rather than high-altitude supersonic attackers. Four feet long and three inches in diameter, it weighs only 28 pounds complete with its launcher.

Redeye's heat-seeking guidance is wholly self-contained. Reaction time is little more than it takes the soldier to lift the launcher to his shoulder, find the attacking aircraft in the sighting scope and squeeze the trigger. By that time, Redeye's infrared sensor has locked onto the source of heat it must follow.

A small charge projects the missile from its launching tube. At a distance far enough to protect the soldier from rocket blast, a fuse lights the major rocket charge. Miniature computer circuitry within the missile directs a set of steering fins which enable Redeye to change direction as necessary and chase the target at supersonic speed until it intercepts it.



Redeye launcher



Redeye missile (4 feet)

During the long history of combat, the advantage of surprise has almost invariably lain with the attacker. The modern tactical missile now more than evens the odds for the defender. At General Dynamics we are already developing newer ones with still more punch.

General Dynamics is a company of scientists, engineers and skilled workers whose interests cover every major field of technology, and who produce: aircraft; marine, space and missile systems; tactical support equipment; nuclear, electronic and communication systems; machinery; building supplies; coal, gases.

GENERAL DYNAMICS

Soviet Missile Subs Patrol Off U.S.

Two boats, believed to carry 3-4 missiles each with ranges of 350-500 mi., have approached to within 300 mi. of coasts

by Michael Getler

TWO SOVIET submarines equipped with guided missiles are now on patrol roughly 1,000 miles from the United States mainland, according to high-level U.S. Navy sources. One is off the Atlantic coast, they report, and the other is operating in the Pacific.

Both have left station periodically and moved to within 300 miles of each coast. Each submarine is estimated to have three or four missiles with a range estimated at 350-500 mi.

The submarines now on station are believed to have entered their patrol areas several months ago, and are probably the first to take up station on a continuous basis.

Top-level Navy sources estimate that within the next two years, the Soviets will increase their continuous on-station patrols of both U.S. coasts to a total of at least 10 submarines. "They have the capability to do this now," these sources state.

Officers also expect that some of these may not be missile-equipped but may be older, more conventional submarines that could serve as decoys against U.S. antisubmarine warfare forces.

Navy officers told MISSILES AND ROCKETS that surveillance of the two submarines now on station "has been fairly good."

Word breaks—Most recent open indication of increasing Soviet long-range submarine activity came late last month in testimony before the Senate Armed Services Subcommittee on Dept. of Defense Appropriations for the Fiscal Year 1967 budget.

At that time, Chief of Naval Operations Admiral David L. McDonald said "Russian submarines have begun deploying in ever-increasing numbers throughout the world. Worldwide 'unidentified' submarine contacts, that is, out-of-area type contacts, have more than doubled in the past two years."

Other high-ranking officers told M/R that there are now between 12 and 15 Soviet submarines cruising outside of their traditional operating areas. Two-thirds of these are in the Atlantic and Mediterranean.

Though the Soviets have always had a large submarine fleet, it is only recently that they have ventured beyond normal defensive perimeters. Four to five years ago, say Navy officers, there were virtually no Soviet subs operating at long distances from their home ports.

There was, however, an extensive ocean survey program, which basically laid out the routes and operating areas Soviet submarines could use once a long-range operating capability was introduced.

In the past several years, U.S. surveillance has shown a very large increase in the training of Soviet submarine crews for long-range patrols. The three principal fleets carrying out these operations are based in the Barents Sea, Black Sea, and the Sea of Okhotsk on the Soviet Pacific shore inside the Kuril Island chain.

From Barents Sea ports, such as Murmansk, submarines have been cruising south on 4,000-5,000-mi. training patrols into the Mediterranean. From Black Sea ports, Navy officers say, the Russians have been cruising beyond the Mediterranean and then north in the Atlantic for another 1,000 mi. From the Pacific port of Vladivostok, Soviet submarines have been making progressively longer forays into the Pacific Ocean.

"In the past year," says one top officer, "they have just straightened out these training routes and begun the long-range operational patrols off both our coasts." There are also at least two or three Russian submarines which operate continuously in the Mediterranean.

The current Soviet submarine force described by Adm. McDonald in his testimony totals more than 400, "more than half of which are modern long-range types, including a steadily increasing percentage of nuclear-powered units."

Breakdown—Specifically, Navy analysts report that there are now 45 nuclear-powered submarines in the Soviet fleet, about 25 of which are missile-bearing. Some of these mount ballistic missiles and some carry the slower cruise types. There are also 45 conventional, diesel-powered long-range submarines which are missile-equipped, some of which carry ballistic missiles but most of which are configured with cruise missiles.

Each ballistic-missile submarine carries three launch tubes. The cruise-missile submarines are configured to carry two, four or six missiles.

In total, top-level Navy sources estimate, the Soviets now have more than 100 submarine-based ballistic missiles and 200 cruise missiles, all with ranges of at least 350 mi., carried aboard vessels with sufficient cruise range to reach U.S. shores and return.

There is still no hard evidence, Navy officers say, that the Soviets have an operational underwater launch system that is deployed on even a modest scale. It is believed that those submarines now on patrol, and the large majority of other Soviet missile submarines, would have to surface before firing. However, Navy analysts point out that the requirement for underwater launch is far less pressing for the Soviets, with only three ballistic missiles per submarine, than it is for the U.S. *Polaris*-carrying submarines, which house 16 missiles and therefore may have to hide and move during a much longer firing period.

Navy sources say there is evidence that the Soviets are developing a better, longer-range missile for their submarines, though it appears to be of considerably shorter range than the early versions of *Polaris,* which could travel 1,200 miles. They also add that there is no evidence that a larger-class missile-firing submarine is under development.

Naval officers say the Soviet submarine fleet probably will remain numerically the same in strength over the next several years, adding roughly 10-20 boats of all classes each year and phasing out an equivalent number of older ones.

The Chinese Communists are credited with having more than 30 submarines, but almost all of these are the older, Russian-built "W" types. But U.S. officers do not think the Chinese Reds are very good submariners. Navy sources say the Chinese now have one Russian-built missile-firing, diesel-powered submarine, "and probably some early Soviet missiles."

The "W" class submarines are mostly 1950-55 vintage, having a displacement of about 1,000 tons and a range of approximately 12,000 miles. Surface speed is estimated at 16 knots, and submerged speed is believed to be about 13 knots. ■

NASA To Begin Space Rescue Study

Industry expected to get RFP in few months stressing system using existing equipment; Gemini 8 scare triggers pressure

NASA IS TAKING the first step leading to development of a space rescue system.

The space agency is expected to issue a request for proposals to industry in the next few months for a study defining potential emergency conditions of a manned vehicle in space and how a system using existing or future space hardware could be used to meet them.

The space rescue development program will be headed by Edward H. Olling of the space station study office under the Manned Spacecraft Center's Advanced Spacecraft and Technology Div.

It is not believed that the space agency, at this point, has the funds required to develop a space rescue system. But if industry could come up with a feasible system using existing launch vehicles and spacecraft from the *Gemini* and *Apollo* programs, the cost of the system could probably be lowered to the point where the funds might be obtained by reprogramming funds approved for other projects.

A NASA official said last week that the RFP was ready to be issued to industry, but it was apparently later withdrawn because top officials refused to give their approval. Maxime Faget, MSC assistant director for engineering and development, said that MSC is currently wrestling with the work statement and plans to resubmit it to NASA Headquarters at a later date, but declined to say exactly when.

In addition to cutting the cost, the use of existing hardware would sharply reduce the time needed to develop the system. Thus, if the study proved such a system feasible, NASA could skip its usual phased procurement procedures and move directly to development.

Gemini 8 scare—Space rescue, although studied in-house at MSC among the functions of a logistic vehicle supporting a manned orbiting space station, was pulled out for separate study only recently when it apparently became obvious to NASA officials that *Gemini 8* astronauts came very close to being stranded in orbit or to facing a very risky ballistic re-entry.

NASA has been under pressure by at least one member of Congress and some U.S. newspapers to develop a space rescue system. Rep. Olin Teague (D-Tex.), according to press reports, demanded action after the successful March 16 recovery of *Gemini 8* astronauts Neil A. Armstrong and David R. Scott after an almost-catastrophic failure in space.

The *Gemini 8* spacecraft began to tumble out of control because of a stuck thruster shortly after the first successful link-up with an *Agena* target vehicle in space, forcing the crew to undock and to use the re-entry control system (RCS) to dampen an excessive roll rate of 360 degrees per second.

Depletion of RCS propellant in orbit would have denied the crew attitude control during re-entry. RCS thrusters are used to hold the spacecraft in proper attitude during contact time of retrofire, and to keep the blunt end forward to allow the heat shield to bear the brunt of re-entry heating. Without attitude control, the spacecraft could become aerodynamically unstable during re-entry, inducing a tumble that could endanger the crew and spacecraft to high-g structural loading and the risk of burning up.

Under terms of the study, the contractor will be called upon to classify emergencies from the standpoint of time necessary to effect a rescue. An MSC source told MISSILES AND ROCKETS that a space rescue system, in order to cover all possible emergencies that may arise in *Gemini* and *Apollo* missions, would have to be designed for the "worst case."

Possible launch vehicles—This would demand a delta-V capability that could steer out of large out-of-plane (60° maximum) and out-of-phase (360° maximum) differences, as well as brute force propulsion that could match orbital eccentricities and orbital axes to accomplish a rendezvous in the minimum amount of time. Such a capability, he said, is far beyond the *Gemini-Titan II* combination, but begins to look "feasible" with a modified *Gemini* mounted atop a *Saturn V*.

A make-shift system using the *Saturn IB* or the *Titan III* launch vehicles might be used to cover most emergency situations in Earth orbit.

Space rescue systems are now feasible because most of the things required of them—rendezvous, docking and walking in space—have all been proved to be fairly easy space maneuvers.

While there is no launch vehicle in existence that can generate the required high delta V to cover all emergency situations, this could be compensated for by launching at a time when the rendezvous can be achieved quickly.

Spacecraft proposals—One of the systems proposed calls for adding a seat to the *Gemini* spacecraft so that it could be launched with only one man at the controls on rescue missions involving two astronauts.

Another calls for launching an unmanned spacecraft—carrying additional oxygen, water, food and power supplies—so that stranded astronauts could stay in space until a manned rescue vehicle arrives.

A third proposal calls for adding a seat to the *Apollo* spacecraft so that it could be used in rescuing three-man astronaut teams. ■

Humphrey Suggests International Mars Landing

VICE PRESIDENT Hubert Humphrey has called for the first manned voyage to Mars to be an international undertaking.

In a speech prepared for delivery March 28 at the AIAA Stepping Stones to Mars meeting in Baltimore, the Vice President said that the United States would welcome ideas of scientists and engineers from other countries on the best way to reach and explore Mars.

"This enterprise is of such tremendous, such breathtaking scope that there is ample opportunity for many nations to contribute to it, each in its own way," the Vice President said.

Humphrey indicated that the U.S. plans to "press vigorously forward" with ever-wider international cooperation in the space field. Apparently mindful of the recent budget pinches the space program has been feeling, he spoke of the opportunity to supplement U.S. resources "in minds and money, furthering our shared adventure into space."

Mariner '69 Support RFP Imminent

Industry to have bigger share in development than in previous Mars missions; contractor selection expected in three months

by Hal Taylor

A REQUEST FOR PROPOSALS from industry for the systems support contractor for development of the 1969 Mars exploration spacecraft will be issued by NASA within a month.

Donald P. Hearth, director for planetary flight programs, told MISSILES AND ROCKETS that a contractor will be selected for the job in about three months.

Total cost of the 1969 Mars unmanned exploration spacecraft is estimated by the space agency to be $98 million. The project now calls for two spacecraft to be launched on fly-by missions of the red planet during the February, 1969, launch window.

The program is under the technical direction of the Jet Propulsion Laboratory. JPL also directed the space agency's successful *Mariner II* fly-by of Venus on Aug. 27, 1962, and the *Mariner IV* fly-by of Mars on Nov. 24, 1964.

The 1969 Mars program, however, will have far greater industrial participation than the previous spacecraft development programs (M/R Feb. 21, p. 14).

Addition of a systems support contractor is the major change. No decision has been made yet as to just what function the winning firm will have. The question relates primarily to how much relatively simple support work, such as design and technical assistance, the contractor will perform and how much actual hardware fabrication it will do. Officials at NASA Headquarters, JPL, and Lewis Research Center —responsible for technical direction of the project's *Atlas/Centaur* launch vehicle—are expected to make a final decision on the scope of the systems support work in the next two or three weeks.

Increased subcontracting—The other major change is the addition of a large number of major subcontractors to the spacecraft development team.

Some of the major subsystems which will be developed by industry are guidance and attitude control, communications, propulsion, power supply, data processing and TV camera system.

Hearth said that all of these subcontractors will be selected and onboard by the fourth quarter of this year. Some of them will be named much earlier in the year in order to assist JPL with the finalization of spacecraft and subsystem design, he added.

Another major subsystem which may become part of the program is a probe which would be sent from the spacecraft into the Martian atmosphere. The House Space Committee recently approved extra funds in the Fiscal Year 1967 budget for the probe, but there is some question as to whether the Senate Space Committee will go along with the action.

In addition, Edgar Cortwright, deputy associate administrator for space sciences and applications, said recently that the space agency would have to have assurance from Congress right now that extra funding would eventually be approved. This would permit NASA to reprogram funds for the project so that the 1969 launch window schedule could be met. Since it is expected that Congress will not complete action on the space agency budget for two or three months, any Congressional assurance of funds at this time is unlikely.

The *Mariner* 1969 spacecraft will weigh 700 to 800 lbs., compared to the 570-lb. weight of *Mariner IV*.

Experiments—The 1969 vehicle will carry 70 lbs. of experiments, and will have a 30-lb. scan platform experiment.

Proposed experiments for this mission include infrared, ultraviolet and television scanning for atmosphere and planetary surface observations, plus experiments for measurement of interplanetary and planetary fields and particles. An occultation investigation similar to that performed by *Mariner IV* will also be conducted. This combination of experiments and investigations will add considerably to present knowledge of the planet.

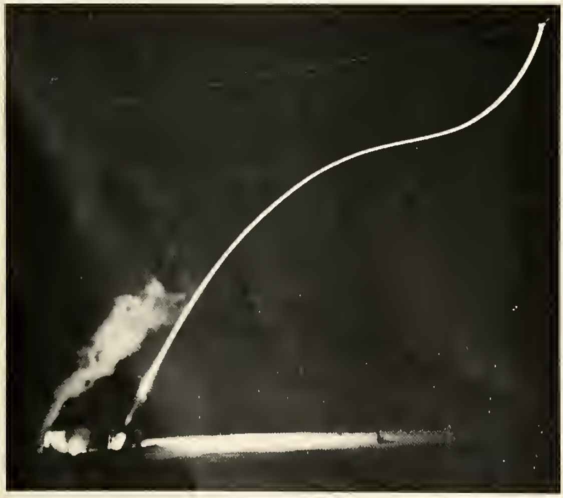
The 1969 mission will follow a sequence of events similar to those of *Mariner IV*. Flight times and communication distances will also be comparable to those associated with the 1964 Mars mission.

It is expected that many of the JPL personnel who participated in the successful *Ranger* program will be employed in the Mars project.

JPL has also been assigned systems management responsibility for the spacecraft, tracking and data acquisition and mission operations.

The schedule for implementation of the *Mariner* Mars project calls for completion of systems design in July, 1966, delivery of the proof test model in November, 1967, delivery of two flight spacecraft in June, 1968, and launch about mid-February, 1969. ■

Redeye Scores Kill in Alaskan Tests



Twin streaks in sky dramatically show Army's Redeye air defense missile intercepting target drone in tests at Fort Greely, Alaska. Light straight line at top is drone's path during time exposure.

House Unit Gentle with NASA Funds

THE HOUSE Space Committee wound up action on the NASA authorization bill late last week, giving the budget the most tender treatment it has received at the committee's hands for years.

As the full committee prepared for a final vote, the size of the reduction being considered ranged from $23.6 million to $32.7 million in a total request of $5.012 billion.

Still pending March 31 was disposition of a $9.1-million lunar sample receiving laboratory, which the space agency has proposed locating at the Manned Spacecraft Center. The Manned Spaceflight Subcommittee voted to defer the project on the basis that NASA had not provided adequate justification for it.

However, this action was appealed by NASA, and a second vote was to be taken after an additional closed hearing with NASA officials.

Other cuts approved by the full committee included a deferment of $581,000 for a hazardous operations laboratory at Marshall Space Flight Center, and $6.7 million in various classifications for manned spaceflight administrative operations.

Increased funding—The committee added $7.5 million for the 260-in. solid motor development program and $2.4 million for the SNAP-8 nuclear electric generator program. It also added $2 million for aeronautics and $200,000 for the technology utilization program. However, some $13.9 million was cut from the tracking and data acquisition account, $5 million from construction at the Electronics Research Center, and $9.4 million in administrative operations.

Recommendations by the Space Sciences and Applications Subcommittee that $42 million be reprogramed within the request of the Office of Space Sciences and Applications were also approved by the full committee.

This included the transfer of $20 million to a landing probe for the Mars *Mariner* fly-by in 1969 and $22 million to preliminary work toward *Voyager*. The committee ruled that this money should come from cancellation of an $18-million fund for a 1967 *Venus* fly-by, $1.5 million from the *Orbiting Astronomical Observatory* program, $10 million from launch vehicle procurement, $5 million from supporting research and technology, and $3.5 million from administrative operations.

Anti-SLBM Being Developed Using Surplus Army Redstones

THE NAVY is developing a defensive weapon system against sea-launched ballistic missiles.

First official indication of this came last week in testimony before the Senate Armed Services Committee by Robert W. Morse, assistant secretary of the Navy for research and development.

In a rundown of R&D programs being carried out at the Navy's Pacific Missile Range, Morse specifically mentioned the anti-Sea-Launched Ballistic Missile (SLBM) project.

Existence of the program was first reported in Missiles and Rockets, (Dec. 13, p. 16). The test program involves use of surplus Army *Redstone* missiles launched from PMR as target vehicles and interception by Navy *Terrier* surface-to-air missiles. Several flights have been made, and it is known that at least the first intercept was highly successful.

Navy sources close to the project told M/R that the effort is now regarded as an exploratory development intended to find out what kind of capability for missile intercept is feasible from a shipboard platform. They report that they are optimistic about test results achieved in the program thus far.

Principal intent of the program is to integrate a Navy terminal defense system for coastal targets into the overall damage-limiting concepts being developed under the continental U.S. ICBM defense program.

Use of the *Terrier* is viewed as only part of the exploratory development. Navy officials say that the more advanced surface-to-air missiles under development, such as the *Standard Missile* and the *Advanced Surface Missile System (ASMS)*, are tied into this feasibility investigation because of their status as second-generation weapons. However, they say that this is not a specific objective of either missile program "as of today."

Douglas Lists Major MOL Subsystem Contractors

DOUGLAS AIRCRAFT CO., prime contractor for the Air Force's *Manned Orbiting Laboratory*, has announced award of six major subsystem contracts.

Hamilton-Standard Div. of United Aircraft has been chosen to develop the environmental control and life-support system.

Attitude control will be developed by Honeywell, Inc., (M/R, Dec. 20, p. 9).

Collins Radio Co. won the competition for the communications subsystem (M/R, Dec. 20, p. 9). TRW Systems, Inc., will work with Collins as a subcontractor to supply some components and aid in systems engineering.

United Aircraft will also share in another subsystem development through selection of the Pratt & Whitney Div.'s fuel cell for *MOL*.

Douglas has also selected both the Federal Systems Div. of IBM and the Univac Div. of Sperry Rand for continued definition work on the *MOL* data-management system. The firm says the decision on a final single contractor for the system will be made only after this additional definition phase work is completed.

The winners were named March 30.

The effort to develop the environmental-control and life-support system is aimed at providing the *MOL* crews with "shirtsleeve" living conditions during extended missions of possibly 30 days duration. The system controls cabin pressure, temperature, humidity, and composition of the artificial atmosphere. The system will also eliminate atmosphere contaminants.

Douglas reports that work in this area will include a study on the choice between oxygen-helium and oxygen-nitrogen gas combinations for the laboratory atmosphere. Hamilton-Standard was chosen after earlier competition with the AiResearch Div. of Garrett Corp.

Honeywell was selected from three firms competing for the *MOL's* attitude-control system.

Collins Radio's efforts involve both the radio voice links between the *MOL* crew and ground stations and the flow of telemetry and other command data.

Unsuccessful bidders on the fuel cell, which will supply prime electrical power for all lab needs, were Allis-Chalmers and General Electric. ■

Atmospheric Probe Stressed for Mars

Avco design discussed at AIAA/AAS meeting; critics question feasibility and need for probe for '69 Mars mission

by William S. Beller

BALTIMORE—Government and industry officials, attending the "Stepping Stones to Mars" meeting here found that the interest of the participants was largely centered around the current political-technical question of whether to send a probe into the Mars atmosphere in 1969.

More than 600 engineers and scientists took part in the March 28-30 meeting, jointly sponsored by the American Institute of Aeronautics and Astronautics and the American Astronautical Society.

The House Subcommittee on Space Sciences and Applications, chaired by Rep. Joseph E. Karth (D-Minn.), had suggested earlier that the 1969 *Mariner* mission to Mars carry an atmospheric probe (M/R, March 28, p. 18). The subcommittee also suggested that the 1967 Venus fly-by mission be cancelled to provide some of the money for this augumented *Mariner* program. The subcommittee report was subsequently adopted unanimously by the full House Science and Astronautics Committee.

The Karth subcommittee in its report "considers such a (Mars) probe essential" because so little is truly known about the atmosphere of Mars. Yet the planet's atmosphere should be known much better than it is to assist in arriving at an economical design of the *Voyager* lander capsule, an efficient mission profile, and a maximum landed scientific payload. Lacking reliable data about the atmosphere, "the entire *Voyager* landing system will have to be designed for a wide range of atmospheric conditions," says the report.

Ticking off specific contributions a small probe in the '69 *Mariner* spacecraft could contribute to *Voyager*, the report stresses the worth of an early and accelerated look at the sterilization problem common to both missions; the "valuable experience" to be gained in developing a system for separating a capsule lander from the mother spacecraft—something never attempted before—and the high merit in designing a communications relay system from the capsule to the bus and then back to Earth, another technique never attempted and one that "would have to be perfected for the '69 mission."

Summarizing the possible technical contributions of this early Mars probe, the report points out that the "problems we must cope with in *Voyager* will be more clearly defined, our mistakes will be much less costly, and whatever is learned will be directly applicable to *Voyager*."

The rebuttal—Despite the advantages detailed for the probe, some opposition was noted among the scientists attending the conference here although it did not appear to be majority opinion. Strong opposition has also been expressed by some NASA officials, and there has been serious questioning by Congressional sources.

Rumors on Capital Hill persist that NASA Administrator James E. Webb met with some members of the Senate Space Committee to persuade them to accept the NASA program and not be swayed by House Space Committee's acceptance of the Karth subcommittee report.

The points made against the Karth proposal are these: February was the "drop dead" point for developing a '69 Mars probe, and any later starting date would be inordinately costly with no reasonable assurance of success.

Moreover, NASA could not get started on the program, even if it were approved, until at least April or May because it would take that long for the Senate hearings to be completed and appropriations made. And the hardware for the probe would have to be delivered to NASA in mid-1968 in order for it to be ready for launching aboard *Mariner* during the Mars launch window starting mid-February, 1969, and ending 30 days later.

The next Mars window would not come around again for 25 months.

Even if the *Mariner* Mars probe were scheduled for 1969, and the mission were successful, data would not start coming back until late in the year because the trip is 7½ months long. Data would be transmitted for the next three months, judging from the workings of the July, 1965, fly-by of Mars by *Mariner IV*. "By this time, most of the concepts for the '73 *Voyager* to Mars would have been cast in concrete and changes unlikely," a Congressional observer said.

The problem of adequately sterilizing a Mars probe and its various instruments and components brings up the third point made against the Karth subcommittee proposal. NASA recently asked Congress for $1 million to learn enough sterilization technology for the '73 *Voyager* probe. If this is the state NASA is in, then it would not seem possible for the agency to develop a sterile capsule able to make the '69 Mars landing.

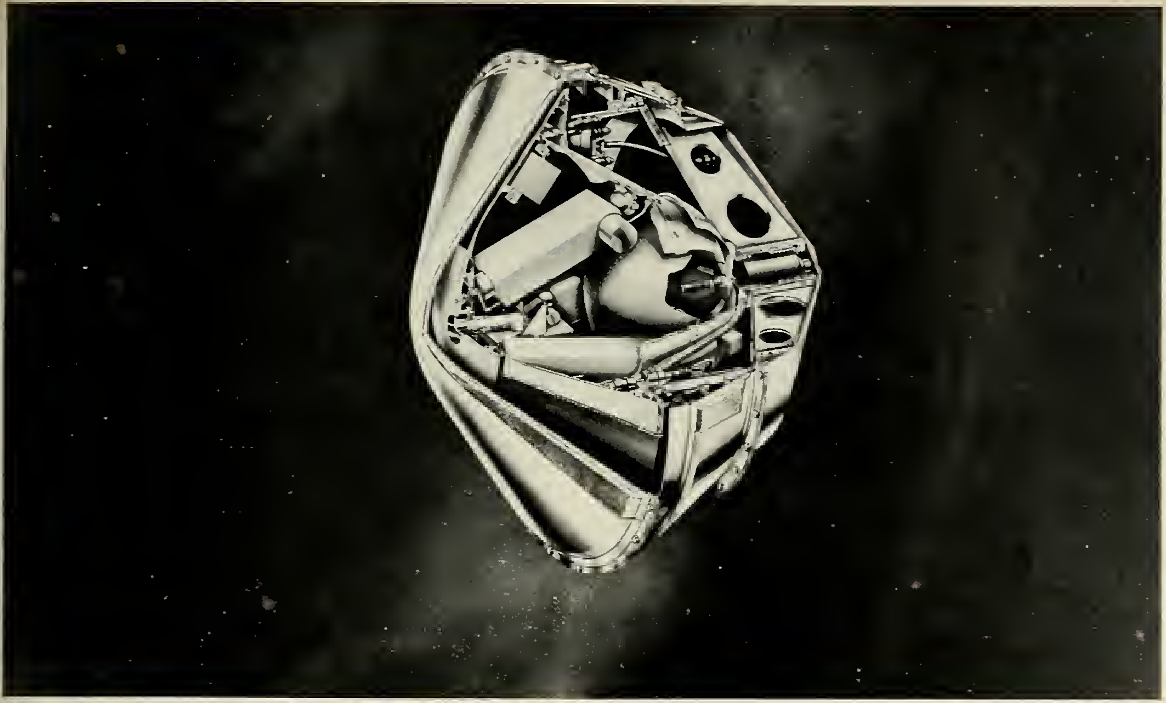
Voyager plans—Donald Hearth, *Voyager* program manager, told the audience that NASA will issue an announcement of flight opportunities in about a year or a year and a half for experiments for the '73 *Voyager* mission. Plans currently approved call for *Voyager* missions to Mars in 1973, 1975, 1977 and 1979. NASA, meanwhile, is studying the possibility of inserting a '72 fly-by into the *Voyager* program and also launch of a lander in the mid or late '70's.

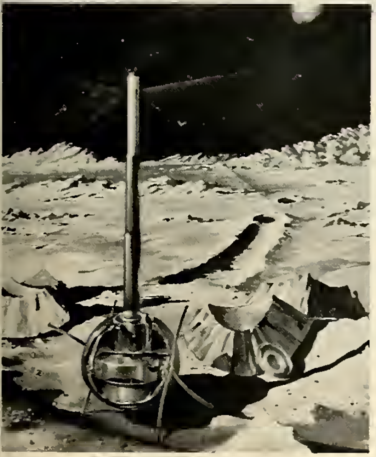
The Mars *Voyagers* sent in the latter half of the '70's will carry automated biological laboratories (ABL) to find out if there is life on the planet. The problem is that the ABL is heavy and bulky, probably weighing between 10,000 and 30,000 lbs., Hearth estimated.

The bulk is presently the critical problem since it is doubtful that two such ABL's will be able to fit on a single *Saturn V* vehicle.

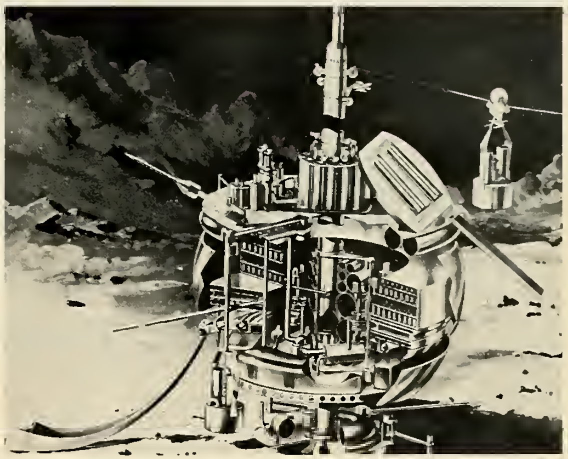
Design of Mars probe—Experts from Ames Research Center and the Jet Propulsion Laboratory have stated to the Karth subcommittee that the '69 Mars probe is certainly feasible and "indicated their support of the undertaking," according to the subcommittee's report. The concept for such a small atmospheric probe originated at Ames about three years ago. After a two-year in-house study, the center went to industry for a preliminary design probe vehicle for this Mars mission. Avco Corp.'s Research and Advanced Development Div. won the design competition, amounting to a $400,000 study contract. The final report will be out by the end of this month or the beginning of May.

Some of the details of the Mars probe vehicle were given by David E. Reese, Jr., assistant chief of the Ames vehicle environment division, and Steven Georgiev, manager, advanced programs, Avco Corp. The study involved a 3-ft.-





ABOVE: Model of Avco Corp.'s 3-ft.-dia. atmospheric probe, which would weigh 50 lbs. and carry 15 lbs. of scientific instruments. LEFT: Mars facsimile camera, developed by Philco Corp.'s Aeronutronic Div., is designed to scan Martian surface after hard landing. RIGHT: Artist's rendering of Philco's automated biological laboratory.



dia., 50-lb. Mars lander able to gather its data on the way through the atmosphere. It would find the density, pressure and temperature of the atmosphere, and also its chemical properties, by means of the radiative character of the plasma sheet surrounding the entering body.

An artist's concept of the probe is shown here and has the shape of a sphere capping the base of a truncated cone. Avco studied two mission profiles, only the first having application to a '69 Mars *Mariner* probe.

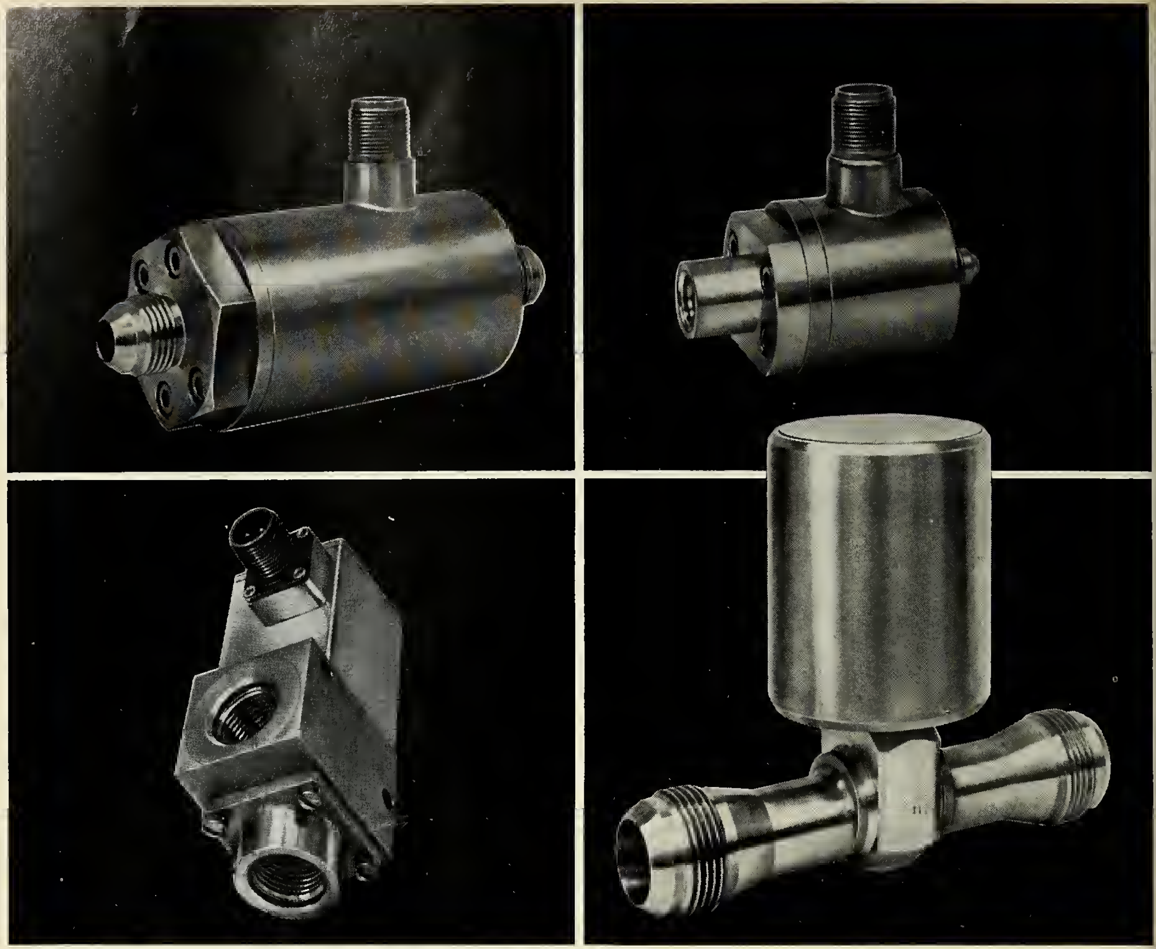
In each instance, a spacecraft carries the probe to the neighborhood of the planet. For direct entry, the probe is ejected from the spacecraft several days before reaching the planet. Upon separation, the probe is spin-stabilized and given an impulse that places it on an impact course with Mars.

"Measurements begin when the probe enters the atmosphere," said Reese in the joint presentation. During the initial portion of the entry when radio communications are blacked out, data would be stored onboard the probe. After the capsule emerged from the blackout, it would transmit the stored data plus real-time data to the spacecraft for relay to Earth.

In the second mission profile, the probe is carried into orbit with the spacecraft. At an appropriate time, the probe is separated, spin-stabilized, and given the impulse that will send it to impact. With these exceptions, the "orbital deployed probe," as the vehicle for this mission profile is described, behaves the same as the direct entry probe.

Sterilization—The sterilization requirements imposed on the probe vehicle call for controls and assays to assure and demonstrate that the total microbial burden does not go over 10^8 organisms at the time of terminal sterilization. Second, the probe system and all its parts and components must be designed to perform properly after undergoing sterilization.

An Avco study showed the burden well below this limit. ■



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ELECTRONICS

Mk II Nav Systems in Response Tests

Two of the navigation-system candidates being flight tested for the F-111 Mark II avionics program have now entered Phase 4 of their evaluation at Holloman AFB, N.M. Aim is to find out the accuracies obtainable when rapid reaction techniques are applied to the Litton LN-14B and the AC Electronics ASN-47. Both systems are flown in a single F-106. The effects of using the stored-heading mode and thermal preconditioning will be tested individually and together. Eight flights are scheduled to be finished this month. Phase 4B tests of these systems in combination with a Doppler system and Phase 4C tests on the effects of use of optimum filtering techniques are possible.

WSMR Impact Prediction Improved

Responsibility for impact prediction for *Aerobee-350* rockets launched at White Sands Missile Range, N.M., has been assigned to the Army Electronics Command Atmospheric Sciences Office there. The real-time impact prediction used for *Athena* is being re-designed, for if applied directly to the *Aerobee* problem, the dispersion of its predicted impact points is greater than the width of the range. The overall sensor system will be improved and predictions will be carried out on a high-speed digital computer. Tentative plans foresee operation of the new system within about 18 months, WSMR officials claim.

Gospodin, Is Anybody Out There?

A conference held in the Soviet Union at the Byurakan Astrophysical Observatory reportedly has worked out two basic directions of experimental work in the search for extraterrestrial civilizations. According to Mikhail A. Klekotko, of the Shternberg State Astronomical Institute in Moscow, they include systematic search for artificial signals from objects at a distance of about 1,000 light-years, including the sending of signals to possible correspondents, and the search for signals from substantially more developed civilizations through detailed study of point sources of cosmic radio radiation suspected of being artificial ones.

OPTICS

AF Develops Low-Cost Vacuum Gauge

Using an inexpensive commercially available optical interferometer of the Michelson type, Air Force Cambridge Research Lab scientists have perfected a new pressure gauge based on the Rayleigh/Fraunhofer gas-refractive-indice measuring technique. Weighing less than 10 lbs., the gauge is useful at and above 10 torr. The inventor is Sheldon B. Herskovitz.

PROPULSION

M-1 Turbopump Tests Completed

The initial tests of the liquid hydrogen and LOX turbopumps for the 1.5-million-lb.-thrust M-1 engine have been successfully completed. The tests covered most of 1965. The Aerojet-General LOX pump develops 27,000 hp and delivers more than 19,000 gal./min. The firm's liquid hydrogen pump reaches 90,000 hp and boosts more than 60,000 gal./min. to the engine. Component testing is the only remaining active portion of the M-1 program. NASA's Lewis Research Center manages the effort.

WSMR To Get Seven-inch Gun Launcher

The high-altitude gun-launched probe program will gain increased caliber at White Sands Missile Range in about two months when a 7-in. gun comes into action. Currently a 5-in. gun is being used to boost chaff, chemicals, acoustic sources, or parachutes to about 250,000 ft. Performance obtained now is very similar to that from *Loki* sounding rockets, except for the 25-30-thousand g initial acceleration. The 7-in. gun is expected to bring this down to about 18,000 g. The smaller gun employs a 5-ft. extension of the barrel. Total cost per firing is about $500 per round. The projectile, carried in a sabot, is a finned dart costing about $250.

Sounding Rocket Payloads Increase

A new series of sounding rockets is appearing for putting payloads of about 10 lb. up to altitudes of 250,000 ft. with a single stage. Typical payloads would be an ozone sonde, temperature sensors, or wind sensors. Two solid-fueled rockets of this type just coming into operation are the Rocket Power Inc. *Raven* and the Space Data Corp. *Sirocco*. Development of a liquid rocket of this class, Aerojet's *SSR-1*, was discontinued about a year ago. The Army Missile Command, Huntsville, Ala., is working on an RDT&E rocket similar in concept to the *Sirocco*. It is 5 in. in diameter and has a center burn of about 8 sec. Aim is to take a 12-lb. payload to 235,000 ft. from sea level at an 80° inclination, at a cost of about $500 per round.

SPACE MEDICINE

Heart Functions Studied Automatically

An automated system for cardiovascular monitoring during spaceflight is being developed in the Biosciences Office of NASA's Office of Space Sciences and Applications. The equipment is being designed to withdraw blood samples and analyze them automatically, and to make injections of dyes and similar compounds for measuring cardiac output and other cardiovascular functions. Plasma protein levels will be measured by a refractometer, along with other parameters of heart functions and circulatory action. OSSA is aiming for a better-than-30-day lifetime.

High-G Level Produces Brain Changes

A level of 3.5 g for 30 days has been shown to produce significant changes in the vestibular system of the brain of some animals, a joint NASA study by the Universities of Maryland and Kentucky indicates. The animals, which were placed on a triple toroid centrifuge, showed a sharp decline in the RNA (ribonucleic acid) content of brain cells involved in the control of posture and equilibrium.

Calcium May Have Reflex Role

Studies under way at the University of California at Los Angeles indicate that the calcium level in circulating blood has a critical role in certain of man's spinal reflexes. Decrease in blood calcium leads to a complete loss of these highly important reflexes, NASA's Dr. Homer Newell reports. NASA is concerned with the possibility of changes in calcium metabolism during weightlessness.

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We have designs on Mars. Currently we're working to develop a Voyager bus which could carry a lander there by 1973.

We're also up to many other space projects. Bio-satellite with its crew of monkeys, tradescantia, neurospora and other exotica is slated for several round-trips soon. MOL and its astronauts will see countdown a couple of years later (we were recently selected as a prime contractor). Our simple-bodied Gravity Gradient Stabilization System (1-moving part) has been throwing its brains around for over two years. Other versions are slated for synchronous orbit next year (ATS). And when OAO goes up, it will be oriented by our extremely accurate control system.

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ICO Effort Termed Incomplete Picture of National Program

by Robert W. Niblock

THE "NATIONAL OCEANOGRAPHIC PROGRAM," prepared annually by the Interagency Committee on Oceanography (ICO), does not really reflect the national effort in the field.

According to Dr. William J. Hargis, director of the Virginia Institute of Marine Science, Gloucester Point, Va., the program as presented by ICO should be entitled the "Federally Funded Program in Oceanography."

Hargis's views conform with the widely held opinion that the ICO program falls short because it fails to include state and industrial programs in oceanography and the classified Navy effort.

In addition, only those portions of the Federal effort which ICO chooses to consider part of the national oceanographic program are considered. One source says that ICO has "knuckled" somewhat to the pressure for a more comprehensive description of the national program by including a number of ocean engineering projects, such as Project Mohole, in its still-unreleased 1967 program.

Hargis feels that there already is too much fragmentation in the national program. Instead of encouraging new activities to undertake new projects, an inventory should be taken to determine what our national capabilities really are in ocenography, he suggested. Such an approach has been outlined by Rep. Paul Rogers (D-Fla.), whose recommended 15-man study commission to consider all aspects of the national oceanographic effort is incorporated in an oceanographic bill passed by the House of Representatives last fall.

As it now stands, Hargis says, a large number of institutions representing a major percentage of the oceanographic effort are never consulted. "There are simply the 'ins' and the 'outs'," he says, so far as the decision-making process in oceanography today.

Single management opposed—In regard to the management of the national oceanographic effort, Hargis opposes a program which would be tightly controlled by one central agency or group. Oceanography by its very nature is too broad for a mono-management approach, he explained.

The Virginia Institute of Marine Sciences, according to Hargis, probably is the largest state-supported organization of its kind on the East Coast. Its budget for the biennium is about $1.4 million—$684,000 allotted for 1966 and $709,000 for 1967. Another $500,000 will be spent during the period for capital outlays and Hargis expects another $300,000 to $400,000 for Federal grant and contract work.

Founded in 1940 as the Virginia Fisheries Laboratory, VIMS' original purpose was "to undertake research useful in the management of the seafood and sport fishing industries." At that time, it was part of the College of William and Mary and served as the research agency for the Virginia Commission of Fisheries.

In 1962, the Virginia General Assembly restated the functions of the laboratory, assigning it additional responsibilities for basic and applied research in the marine sciences and marine technology. It was renamed the Virginia Institute of Marine Science at that time.

VIMS studies the tidal waters of Virginia and the contiguous waters of the Atlantic Ocean. Its ocean research ship ranges as far north as Cape Cod and south to Cape Hatteras—the area described by Captain John Smith as the "Virginia Sea."

The principal research ship is the 55-ft. Pathfinder, built in 1957 for coastal research work. It is now used for deep-ocean work, marking regular stations over the Continental Shelf as far out as the Gulf Stream. VIMS converted an 80-ft. ferryboat to a platform and floating laboratory for Chesapeake Bay work. Also used are seven other boats of the 35- to 45-ft. class.

James River model—One of VIMS' more ambitious projects is a newly constructed $300,000 model of the James River built to study what effect dredging the James River channel from 25 to 35 ft., then to 45 ft., would have on salinity intrusion into the river. A change in the salt-to-fresh water ratio, a likely result of the dredging, is of major concern to the profitable James River oyster industry and industries located along the river edge, which require fresh water for processing work.

The model is at the Water Experimentation Station of the Corps of Army Engineers at Vicksburg, Miss., where 14 or 15 estuarine models are situated. Engineers will maintain and operate the model for VIMS scientists.

The model, Hargis says, will be valuable for both the study of the effects of the proposed dredging and for general studies of the river's characteristics. "With this model," he says, "we can move forward or backward in time." For example, they can simulate the river's condition before altered by man and can project ahead many years to determine how man's use or misuse of the river will affect it. They also can study such things as the circulation characteristics of the James under different conditions of fresh water flow. Funds have been authorized by the Corps of Army Engineers for a similar model of the Chesapeake Bay, Hargis said.

VIMS is located on the York River about 33 miles from the open ocean. It employs 35 to 40 scientists and about 60 support people. In addition, some 40 students work on projects there in connection with their marine sciences' studies. VIMS offers marine science courses to students of both the University of Virginia and the College of William and Mary.

Although its studies are diversified, about 50 to 60% of VIMS' work is marine biology. The major resources of the ocean are biological in nature, Hargis explained; marine biology is basic to studies of water contamination and establishment of water quality standards.

"Biological problems," said Hargis, "are the most difficult to attack. To understand biological systems, you must understand the physical and chemical properties of the water." This need for basic ocean knowledge explains VIMS increasing physical, chemical and geological studies.

The rapidly expanding facility has five buildings, housing laboratory facilities, lecture rooms, administrative offices and electrical, machine and woodworking shops. Two large piers jutting into the York River provide docking for its research vessels and space for a laboratory building. VIMS also has a field laboratory at Wachapreague on the eastern shore of the Chesapeake Bay.

A three-story laboratory building is planned, which will increase the present lab floor space by about 75%. ■

Cold Welding Promises Means To Bond Dissimilar Metals

by John F. Judge

COLD WELDING—the adhesion of metal surfaces to each other in hard vacuum—may be a relatively convenient joining technique.

Studies of the solid-state adhesion of metals have been conducted by National Research Corp., Cambridge, Mass., for several years under funding from both the Air Force and NASA.

Actually, the research was undertaken in an effort to prevent such adhesion by identifying the more important variables controlling the bonding mechanism. The general objective of the NRC programs has been to acquire information as to the conditions under which engineering materials and alloys will bond with sufficient tenacity to hinder relative motion or subsequent separation.

The adhesion, caused by the space vacuum, could cause malfunctions in devices such as bearings, solenoids, valves, slip rings, mating flanges, and conical rendezvous mating surfaces.

On the other hand, metal-to-metal bonds formed by cold welding avoid the formation of heat-affected zones and permit the joining of dissimilar metals which normally are extremely difficult to bond by other techniques.

The experimental studies at NRC indicate that the cold-welding phenomenon is of general application for a wide range of engineering materials.

Considerations—On the positive side, the criteria which must be met in addition to a vacuum level below 10^{-8} torr are:

—*Surface cleanliness*—The strength of the weldment is directly related to the density of metal-to-metal bonds. Thus the presence of oxide or organic films must be avoided.

—*Plasticity*—Ability of the contacting surface to plastically flow is necessary to bring the surfaces into close atomic contact and to relieve elastic restoring stresses generated in local areas of initial contact. This particular requirement explains the relative difficulty in cold-welding strong metals with limited ductility—such as tungsten or high-strength steels—compared with softer metals such as aluminum and copper.

—*Temperature*—Increasing the contact temperature tends to lower the yield stress and increase ductility. NRC researchers find that an increase in temperature to values above half the melting point leads to extensive diffusion bonding across the interface.

The NRC test procedures used vacuums below 10^{-8} torr, since the kinetics of oxide formation are directly proportional to the oxygen partial pressure and these vacuum levels maintain oxide-free surfaces for a finite time.

Several surface-cleaning techniques were investigated. Wire-brush abrasion proved to be a simple, useful method for removing impurities films from test surfaces in vacuum, although transfer of brush material as well as surface scoring and roughening was encountered.

NRC investigators also found that strong adhesion forces over large areas may be attained by applying surface-contact stresses equivalent to the yield stresses of the metal components. Compressive test assemblies generating up to 2,000 lbs. force were used in the experiments—giving contact stresses up to 50,000 psi.

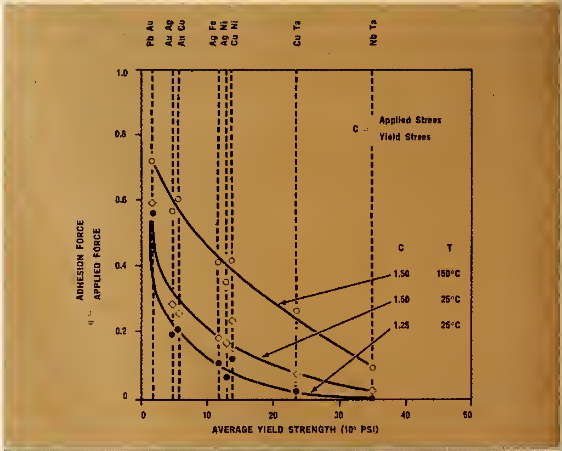
Metals varied—NRC used many metal specimens, including two general categories of dissimilar materials. These categories included materials completely soluble with each other at room temperatures and materials with less than 0.1% solubility. Adhesion was achieved with both sets.

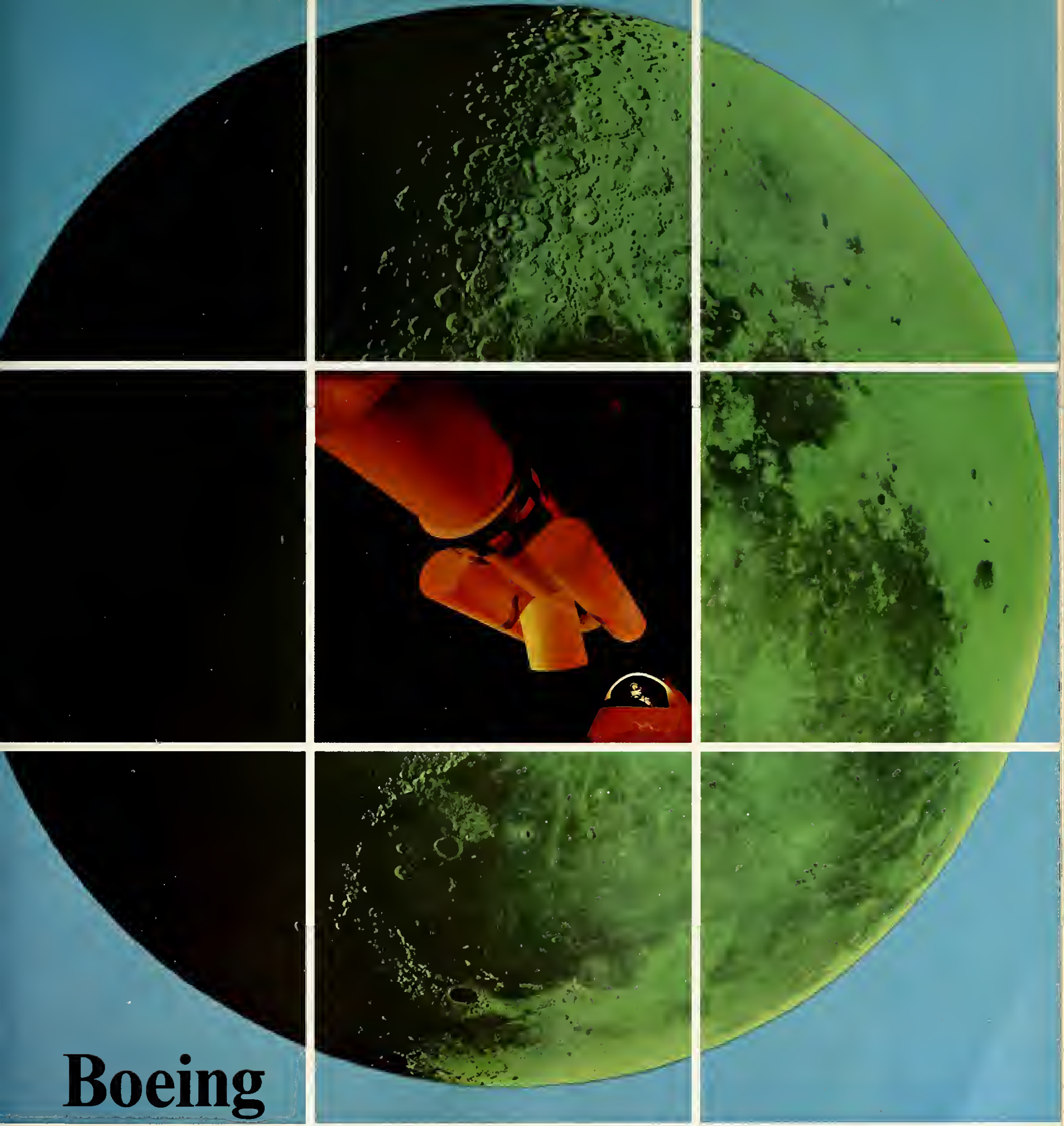
The experimental work also indicates that adhesion is inversely related to the hardness or average yield stress of the material pairs.

NRC is not actively engaged in the development of cold welding as a joining process. The firm is seeking contractual support for such investigations.

The work covering the detrimental aspects of space-vacuum welding leads NRC experts to the conclusion that certain electronic and rare-metal joining might best be accomplished through cold welding. In addition, the technique may be adaptable to in-orbit construction where the creation of a vacuum poses no problem. ■

LEFT: Rough test for adhesion strength shows researcher supporting himself with the aid of two copper blocks cold-welded by National Research Corp. Specimens are level with top of man's head. RIGHT: Adhesion coefficient as a function in yield stress for various sample materials tested in 10^{-8} torr vacuum at NRC.





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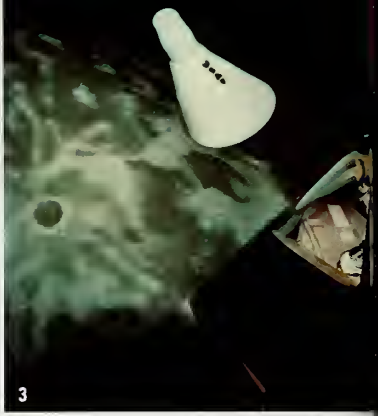

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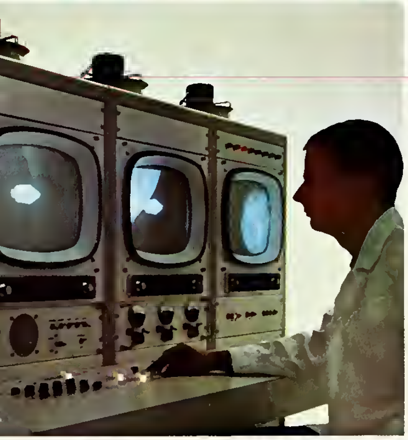

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6

Newest, most advanced space research center in private industry.

For a number of years, space research has claimed a sizable and growing share of Boeing research funds. Many of Boeing's continuing programs devoted to space flight techniques and the design of improved spacecraft, have recently been brought together in the new Boeing Space Center. Located on a 430-acre site between Seattle and Mt. Rainier, the new Center is a complex built around four major laboratories. Space flight simulation and space environment simulation laboratories are located in the building at the left. The materials and processes, and microelectronics laboratories are in the building at the right. Additional facilities and buildings are under construction.

1 View from cockpit of space-flight simulator. Pilots "fly" simulated launches, earth or lunar landings and orbital missions. Simulation includes visual, auditory and other cues to provide sensation of actual space mission.

2 TV camera moves toward earth globe
response to pilot's controls. Computer syste
determines speed and approach angle of camer

3 Moon surface and spacecraft are project
on hemispherical screen. Sky, star fields, oth
planets and selected landing sites can be show
The relative motion of all orbit and missi
maneuvers are realistically simulated.

4 Monitors display images viewed by two T
cameras, plus image of composite scene bei
projected before pilot.

5 Synthetic sunlight from a collimated lig
source produces the nearly parallel light ra

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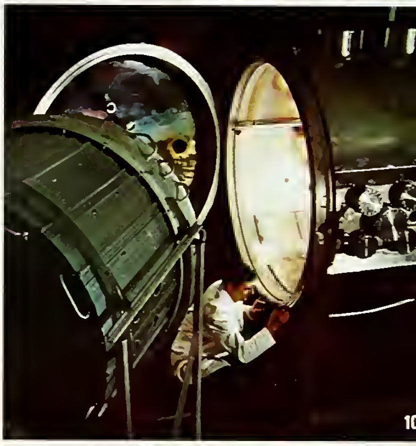

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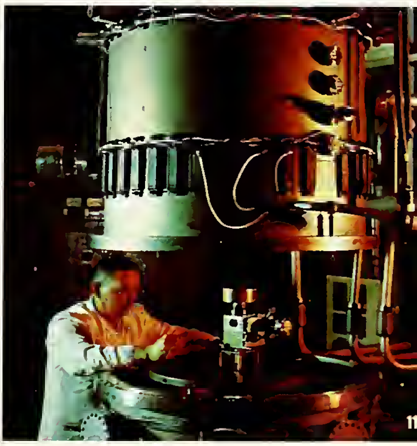

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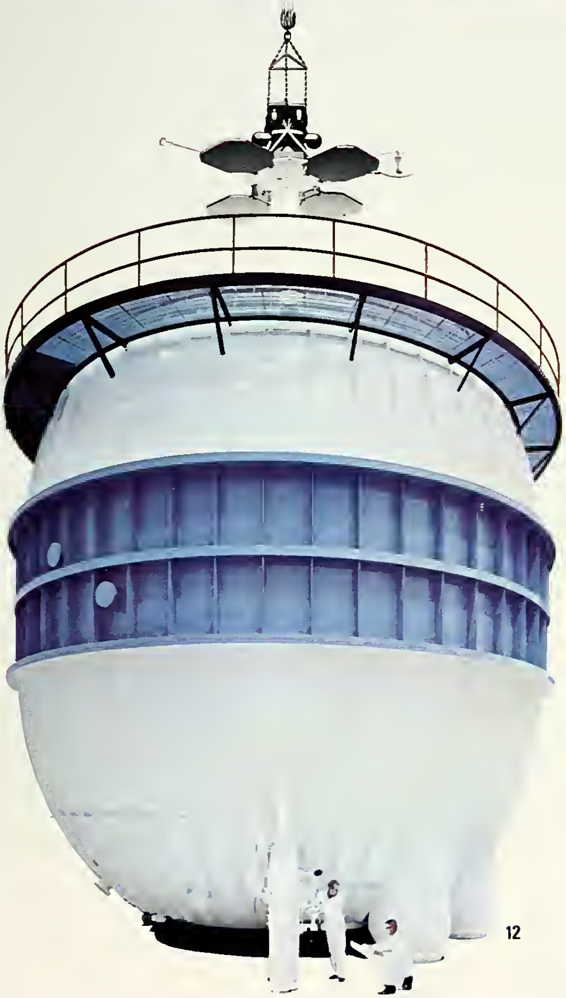


12

at create sharp shadows like those astronauts ould see on lunar surface.

Re-entry and earth landing simulation involves TV camera in computer-controlled pproach to relief map of U.S. coastal area.

Rendezvous and docking simulator includes rget vehicle suspended from movable crane, nd cockpit section that rotates on an air bearing, s motion controlled by reaction air jets.

Simulated space docking maneuver viewed om cockpit. Closing velocities and alignment aneuvers are simulated right up to final dockg with target vehicle. Modular instrument panel includes two-axis attitude indicator.

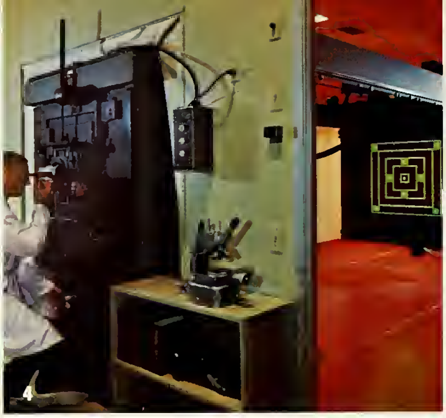
9 Ten-foot vacuum chamber can simulate temperatures and pressures equivalent to those at 600-mile altitude, as well as solar radiation. This radiation is used to test solar cells, spacecraft coatings and materials.

10 Space environment chamber (one of 11 in Center) simulates cold, heat, solar radiation and vacuum of space, to obtain prelaunch operating data on spacecraft and equipment.

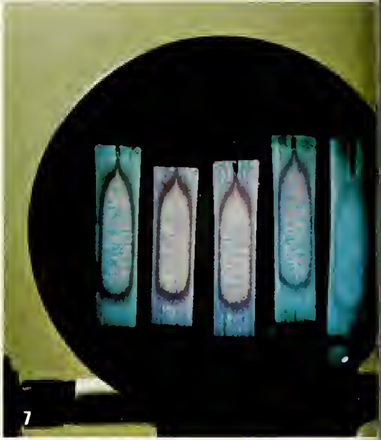
11 Vacuum chamber, ion-pumped to insure contaminant-free environment, is specifically designed for material evaluation and small component testing. Camera lens door mechanism of Lunar Orbiter is being positioned for space test.

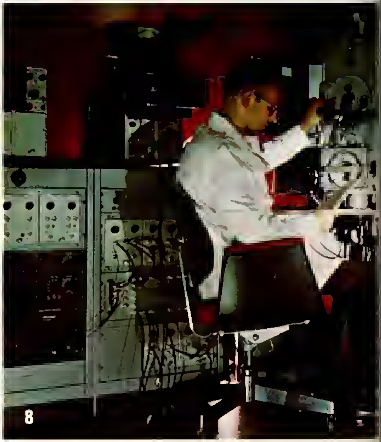
12 Center's largest space environment chamber, pictured at left, is 50 feet high, 39 feet in diameter. It is used to test complete vehicles including NASA's Lunar Orbiter, which is shown being lowered into chamber. A vacuum equivalent to 400-mile altitude can be achieved, plus supercold temperatures of −320 degrees F. Chamber can be used to test manned systems.

BOEING



Boeing Space Center





Microelectronics, materials and processes laboratories.

Microelectronics research and development at Boeing support company programs involving space-age microelectronic guidance, control and communications. Boeing research also develops new materials and processes that can work in the high vacuum, solar radiation and extreme temperature variations of space.

1 Lady bug photographed to give scale to thin film resistors on silicon circuit wafer.

2 Preparing master circuit pattern, which will later be reduced to microminiature dimensions.

3 Melar fixed focus reduction camera used to reduce patterns for integrated circuits, thin film circuits and circuit boards.

4 Photo-reduction camera reduces thin film and silicon circuit master patterns to 1/400 original size. Final pattern lines are as narrow as 1/10,000th inch.

5 Cleaning and inspection of resist-coated silicon integrated circuit wafers before heating to 900 degrees C. in diffusion furnace.

6 Electron beam welder uses fusion process, with heat obtained from dense beam of hig velocity electrons. Welding is done in vacuu chamber to avoid atmospheric contaminants.

7 Metallograph (one of three in Center) pro vides reflected light for study of sections o ceramics, metals, alloys or minerals.

8 Electron microprobe analyzer used for ele mental analysis of minute, solid-specimen sur face volumes. An area of one square micron ca be analyzed.

BOEING

NASA Seeks Breakthrough In Oxygen Recovery Systems

by Heather M. David

NASA SCIENTISTS are attempting to leapfrog the state of the art in life-support systems in an effort to develop a continuous-flow oxygen recovery system based on one relatively simple electrochemical process.

Even the most advanced systems now being perfected involve several separate processes to convert exhaled carbon dioxide back to usable oxygen. These, like that being demonstrated by NASA at its Langley Research Center, involve the absorption and reduction of carbon dioxide followed by the electrolysis of water.

No U.S. manned spaceflight has utilized a life-support system in which oxygen was regenerated from waste products, since the complexity and weight of such equipment has prohibited its use for shorter missions.

As Dr. Walton Jones, NASA's director of biotechnology and human research in the Office of Advanced Research and Technology, said recently, NASA's objective is to find a continuous-flow system which will be relatively unaffected by cabin water vapor.

Other objectives are to achieve simpler control methods and fewer components, which will increase reliability.

The basic system which NASA would like to improve is that for oxygen reclamation. Langley scientists are looking at both solid and molten electrolyte methods, which could replace the succession of processes currently employed in advanced ground systems. As an example, in the General Dynamics-built manned spacecraft chamber simulator at Langley, the cabin air stream passes through a silica gel bed to remove water vapor, a molecular seive to remove carbon dioxide, a Bosch reactor to convert carbon dioxide (with hydrogen) to water, and an electrolysis cell to separate the water into its components.

The solid and molten electrolyte systems could, theoretically, take the cabin air without preprocessing, and produce oxygen with no intermediate steps.

Contracts out—Three contracts currently are being funded by the NASA OART office, according to A. Layton Ingelfinger. These include a study of solid carbonate by the MRD Div. of General American Transportation Co., an oxide combination by Lockheed Missiles and Space Co., and molten carbonate system by Hamilton-Standard Div. of United Aircraft.

Theoretically, Ingelfinger said, the most efficient system in terms of oxygen recovered from carbon dioxide should be one based upon the molten carbonate concept. However, the idea of removing carbon from a molten system in zero gravity presents some perplexing problems.

Several methods of removing the carbon are being studied, including the removal of the electrode from the system.

Another concept involves centrifugation, and a conceptual model has been constructed. NASA plans to construct a model capable of high-temperature operation with the actual electrolyte at a later date.

Water vapor electrolysis—Yet another interesting approach to the recovery of breathing oxygen is that being carried on by NASA's Ames Research Center, which is looking at the possibility of recovering oxygen by electrolysis from water vapor and perspiration exhaled and perspired by pilots.

According to Ames officials, about 3.8 lbs. of water vapor can be procured from each man per day by these means, which is enough to fulfill his daily oxygen needs of approximately 2 lbs.

Both phosphoric acid and sulfuric acid electrolyte cells have been constructed, the former under a contract with Battelle Memorial Institute. NASA estimates that this unit would weigh 10 lbs. per man and require 287 watts per man to operate.

The Battelle unit has been tested for periods exceeding 1,000 hours, and all failures reportedly have been due to failure of other test equipment.

The sulfuric acid cell, however, offers theoretical advantages—even though it has not been carried as far in development. A pilot model of the system has been constructed at Ames by Dr. Theodore Wydevan and Ezekial Smith.

The vapor feed cell operates by passing the humid air into one of two cell chambers. Water vapor is absorbed by a deliquescent, immobilized electrolyte sandwiched between two platinum screen electrodes.

The sulfuric acid electrolyte is retained in a semi-solid state between the electrodes by a gelling agent. A microporous rubber membrane prevents mixing of the hydrogen and oxygen generated in the cell.

Ames scientists say that 100% efficiency can be obtained with the process with lower power than was required in previously developed units. However, NASA scientists also have noted that there is a possibility of contaminant formation at the electrodes of the sulfuric acid cell due to breakdown of the electrolyte.

Control systems—Advanced studies also are under way on the problems of controlling a two-gas-atmosphere spacecraft life-support system, in addition to those based upon mass spectrometry, ultraviolet and infrared.

Westinghouse is performing a contract for NASA on a solid electrolyte oxygen sensor which is emphasizing low power requirements and amounts of reference gas. In the unit, oxygen ions pass through the solid electrolyte from a reference sample of 100% oxygen to the measured gas stream. Oxygen level can be read by the voltage developed.

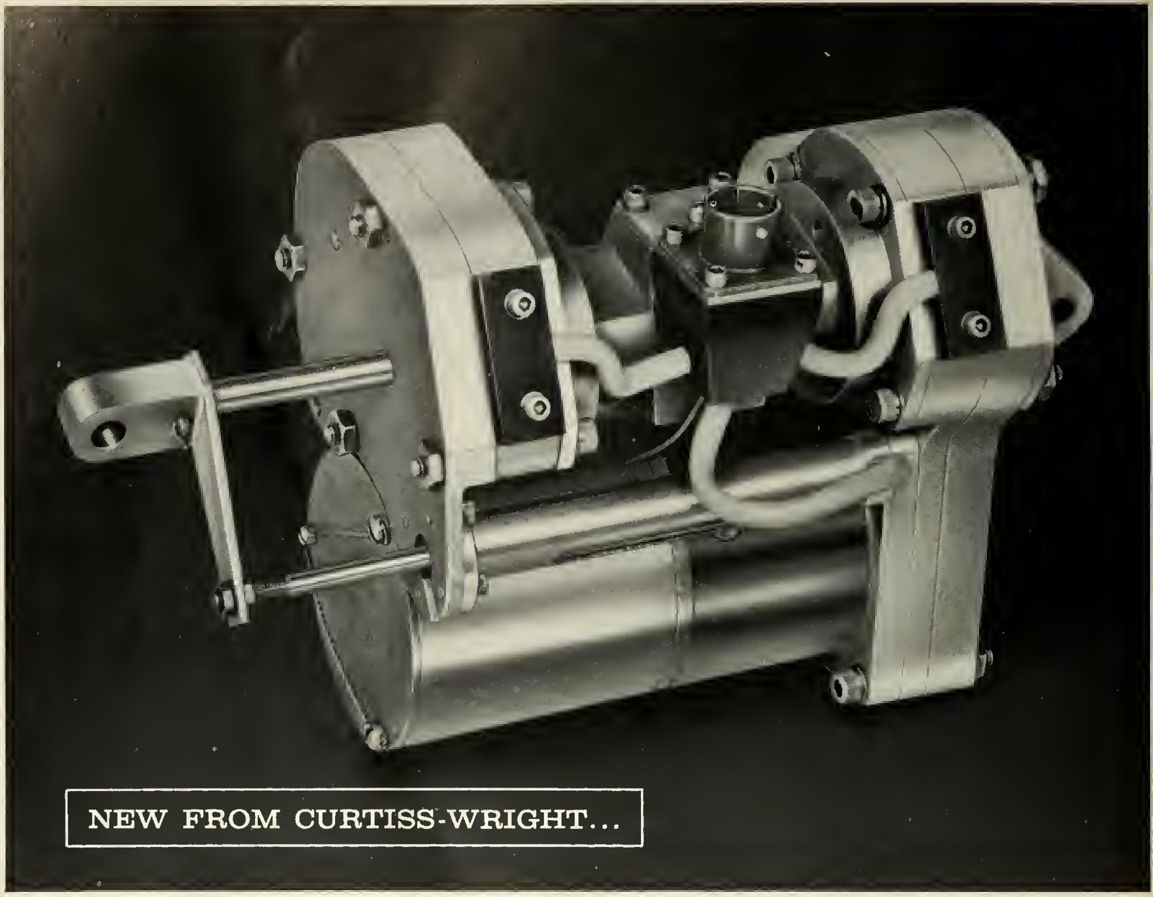
Also under study is a thin-film technique in which the amount of oxygen in the cabin air causes the resistance of a gold film to change, in an observable way. Thickness of this film is only 500 Angstroms.

Contamination removal—An attempt is being made by Langley Research Center scientists to improve the methods of contamination removal by activated charcoal and catalytic burner. This has been studied for some time.

A chamber has been installed at the center in which the effectiveness of new catalysts can be studied. The chamber is heavily instrumented to get precise readings on the level of contamination left in the cabin air.

General Dynamics/Convair also is working on an advanced concept which utilizes freezing as a method of removing contaminants. According to Jones, it may be possible to remove all contaminants by this technique, eliminating or at least greatly simplifying the identification problem.

Langley also is preparing for a succession of manned and unmanned chamber tests with the General Dynamics system, installed last year. Extended manned tests are planned for FY '67. ■



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Radio Astronomy Aired at IEEE

Panelists propose huge receiving array, powerful transmitter to probe for intelligent life; Carpenter analyzes space systems

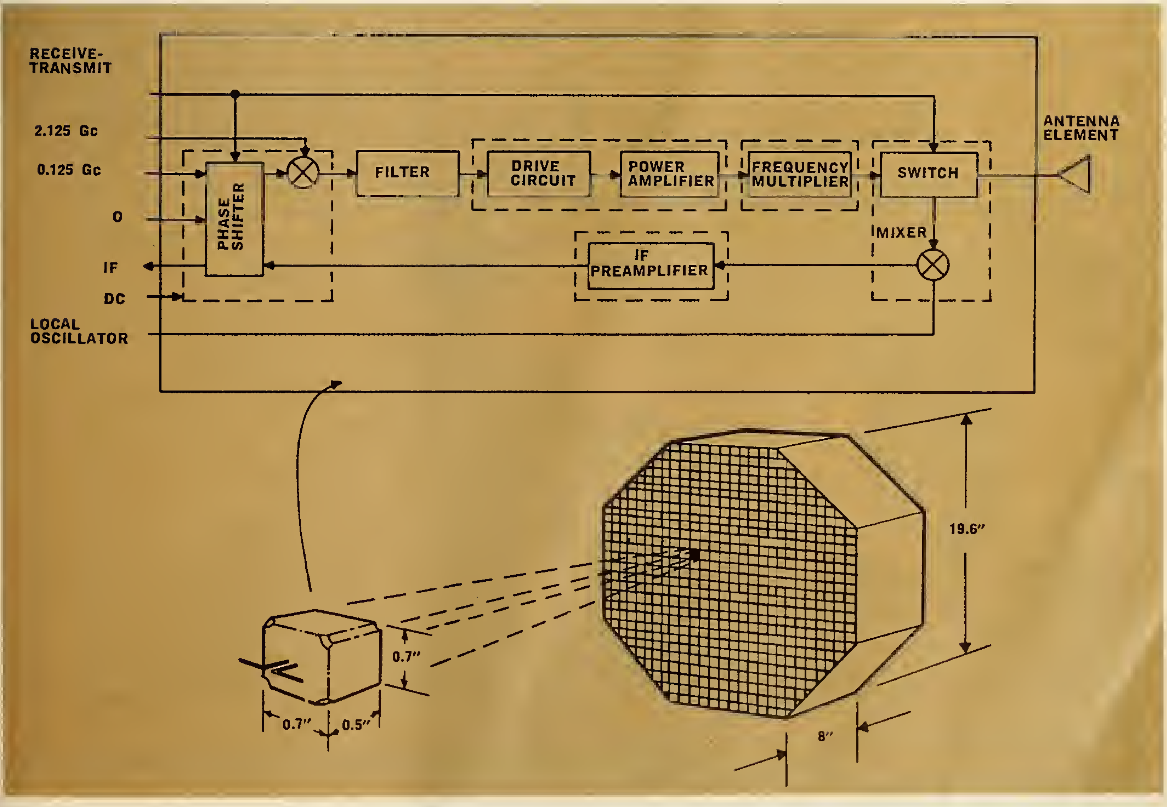
by Charles D. LaFond

New York—A multibillion-dollar program for development of a 10,000-antenna receiving array and a multimillion-dollar effort to produce a smaller transmitting antenna array were proposed here March 22 by scientists to vastly broaden the radio astronomer's capability for probing outer space.

Speaking before the "After Apollo—What?" panel during the 1966 Institute of Electrical and Electronics Engineers' Conference, Dr. Bernard M. Oliver, director of research and development at Hewlett-Packard Co., expanded the concept for a 6-mi.-dia. radio telescope system he first proposed at last year's AIAA conference in San Francisco. Using 100-ft.-dia. dishes randomly distributed but connected to a single receiving center, the system could provide detailed pictures of the radio emissions of nearby galaxies, he asserted.

Co-panelist Dr. William F. Gordon of Cornell University urged that it is now time to start transmitting messages to outer space as a means for locating possible intelligent life within the range of 10 light years from Earth. Cost would be approximately $100 million to build a 10-megawatt radio-telescope array, said the former director of the Air Force Office of Aerospace Research's Arecibo, Puerto Rico, Ionospheric Observatory.

● **IEEE, biggest** ever—The world's largest technical exposition was bigger than ever before. By a re-arrangement



Solid-state phased-array radar concept, under development by Texas Instruments, is shown in this simplified block diagram. Each block of the 600-element array provides transmit/receive/phase-shift functions and is an RF radiator.

of activities—all technical meetings at the New York Hilton and all exhibits at the New York Coliseum—more than 1,250 exhibits, worth an estimated $7 million, were viewed by the more than 60,000 who attended the conference.

During the 80 technical sessions, more than 350 papers were delivered, covering every major aspect of the electronicist's art, including two sessions on undersea technology (M/R March 28, p. 14).

Semiconductors, thin-film and integrated circuits dominated the exhibit area for the fourth year in a row, with a new emphasis on improved production techniques and lower unit costs.

Proposed antennas—The massive antenna complex suggested by Dr. Oliver could be built in four phases over a 10-year period and at a cost of from $3-5 billion. The first phase would involve a feasibility and design study costing several millions. All elements of the system could be built and tested and then site selection and development could begin as phase two, Oliver said.

In phase three, a pilot system using from 1% to 10% of the total number of antennas needed could be built. Thus, with up to 1,000 dishes tied together, the radio astronomer would have a system vastly more powerful than any tools now in use. Phase four would involve continued expansion of the pilot facility to the full 10,000-antenna array.

The full system operated at the hydrogen-line frequency, Oliver claimed, would provide the resolving power comparable to a 1-in. optical telescope, a 2-in. telescope at S-band and a 7-in. telescope at X-band.

In breaking down estimated expenditures, Oliver stated that antennas would be in the $100,000 to $200,000 range for a total of $1-2 billion. Interconnection, computer control, and the receiving station equipment could readily equal or exceed antenna costs.

Dr. Gordon's proposed transmitting array is about 5 to 7 years beyond the state of the art, he said. Radar sensitivity is still the limiting factor, but an 80-db gain over today's best systems would be sufficient for transmitting to distant stars.

Transmission could be made using the hydrogen-line frequency, considered optimal for interstellar communications, and only the equivalent of a 60-ft. dish would be needed to receive the signals, said Gordon.

Space electronics criticized—Instrumentation, telemetry, batteries and inverters, and electrical controls in manned spacecraft generally have performed well in past missions. Significant improvements are needed, however, according to astronaut/aquanaut Cmdr. Scott Carpenter, for stable platforms, voice communications, ground checkout systems, switches, and relays.

Carpenter presented his summary appraisal of capsule and support systems electrical and electronic aids during a standing-room-only session on space systems. All of his comments, the astronaut stated, were based not only on his personal experience but on the results of his poll of the other spacecraft pilots and of a study of all previous flight records.

Inadequacies in voice communications between spacecraft and ground stations drew repeated comment by Carpenter and he suggested to his audience of engineers that they find some way to adapt single-sideband radio techniques to the manned space program. While he admitted that SSB systems have not been employed previously because of limiting Doppler shift, he felt that some means could be found to solve the problem if seriously sought.

The best voice communications obtainable to date, the astronaut claimed, have been in line-of-sight operation and that has not always been reliable. Both range and quality improvements are needed, he asserted, to miminize fading and transmission break-up.

Communications during the re-entry blackout period (through the ionized sheath) have been solved with new equipment but at an intolerable weight

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penalty (30 lbs.), Carpenter disclosed. Finally, he noted the always poor communications prevalent after the spacecraft splashes down. A foolproof antenna extension system might provide a partial answer to this pre-recovery problem, he suggested.

Moving on to other systems problems, Carpenter criticized present inertial-platform design and called for development of a no-moving-part stable table to avoid gimbal-lock problems.

Although present cockpit panel instrumentation has performed well, he suggested that more dual-function equipment be developed. He also proposed redesign of the panel to permit its rotation after the launch phase to eliminate items no longer needed and to introduce newly required units employed in orbital operations.

Better electrical isolation is needed, said Carpenter, to prevent successive systems failure following a single failure.

Power sources—Batteries have been very successful in space missions, he said, but they are still too big and too heavy. He suggested application of SNAP (nuclear-isotope power) systems to manned spacecraft.

The unreliability of switches and relays continues to be a burden, and 75-80% of these units are rejected. Hermetic sealing is poor and both types of components fail under the synergistic effect of space missions (combined zero-g, vacuum, temperature, vibration, etc.).

He also pointed out that the recent thruster control failure during the *Gemini 8* mission appears to be traceable to failure of a microswitch.

Carpenter called for improved design of fluid-temperature measurement devices for operation in the zero-g environment. Better accuracy and higher reliability are needed, he said.

Finally, the astronaut proposed that spacecraft ground checkout systems could be significantly improved and should avoid use of hard-line connections with the vehicle.

Solid-state radar—Any dramatic increase in reliability of military radar will have to be achieved by elimination of mechanical scan and by development of solid-state power generators, according to Tom M. Hyltin of Texas Instruments, Inc.

In discussing a new design approach to phased-array radars during a session on microwave integrated circuits, the TI engineer pointed out that modern multifunctional radar—particularly in aircraft—makes broad use of solid-state design. Up to 99% of the circuits employs conventional semiconductor circuitry or integrated circuits. Through such state-of-the-art design, radar system reliability has been improved significantly, but for further increases, new

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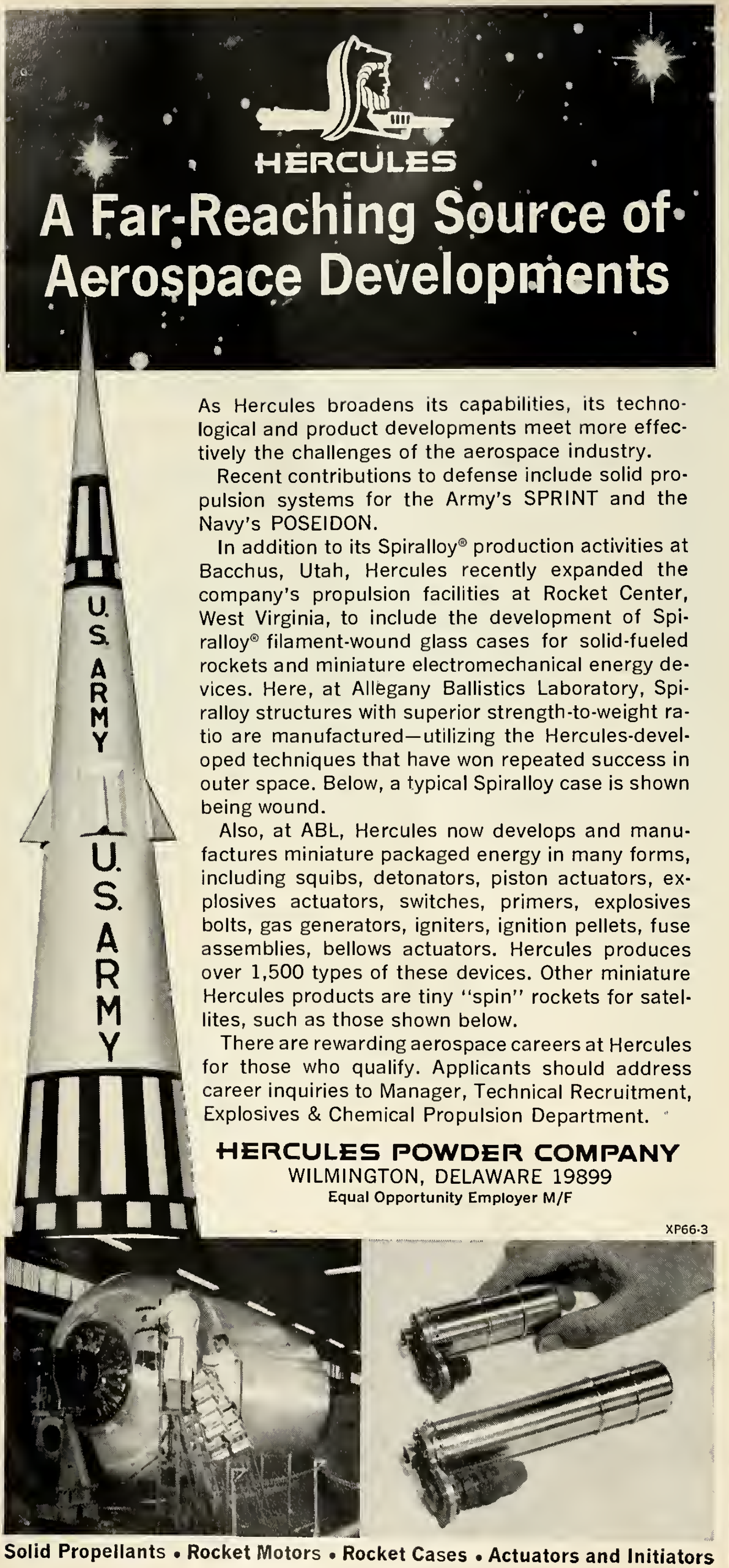

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Also, at ABL, Hercules now develops and manufactures miniature packaged energy in many forms, including squibs, detonators, piston actuators, explosives actuators, switches, primers, explosives bolts, gas generators, igniters, ignition pellets, fuse assemblies, bellows actuators. Hercules produces over 1,500 types of these devices. Other miniature Hercules products are tiny "spin" rockets for satellites, such as those shown below.

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concepts must be adopted, Hyltin declared.

Over half of all present radar failures, he estimated, are associated with the remaining one percent of components. These include magnetrons and klystrons, motors and synchros, mixer diodes, TR tubes, driven potentiometers, and rotary joints—all associated with microwave high-power generation and reception or antenna scanning.

However, application of phased array techniques to radar antenna design not only avoids mechanical scan problems but replacement of the conventional single high-power source with a large number of low-power microwave generators. In addition, Hyltin suggested, employment of pulse compression techniques assures a high average power through use of a high-duty cycle without the need for very high peak power.

A typical forward-looking aircraft radar system, performing the functions of terrain following, terrain avoidance, and ground mapping, might require about 60-kw power at X-band (or higher frequency). Using the design approaches suggested, a comparable system could be designed, Hyltin declared, using a phased array with 600 elements having a 100-watt peak power per element. Such an array, he proposed, would effectively reproduce the results of a single 60-kw source.

By employing a 100:1 pulse compression ratio, he said, the duty cycle could be increased to 0.1, thus reducing the original 60-kw peak power equivalent to 1 watt per element peak for each of the 600 elements. At X-band, such power is readily within the capability of existing solid-state microwave sources, Hyltin said.

Such a system is being developed by TI, and is supported by the Air Force Avionics Laboratory, Wright-Patterson AFB, Ohio.

For a radar operating over the frequency range of 8.5 to 9.6 gc and providing a minimum 50-degree scan from boresight, the engineer calculated, element size in the phased array would be limited to an area measuring 0.7 x 0.7 in.

Each block would contain all the circuitry required for transmit, receive, and phase-shift functions and include an integral RF radiator. While use of conventional components (350 identifiable) would be prohibitive, digital integrated circuit fabrication would result in a volume requirement roughly 0.01 that available, Hyltin said.

The receive portion of the array building block is straightforward, but R&D is continuing to develop the transmit portion, including strip transmission line and high-quality diode and transistor structures. ■

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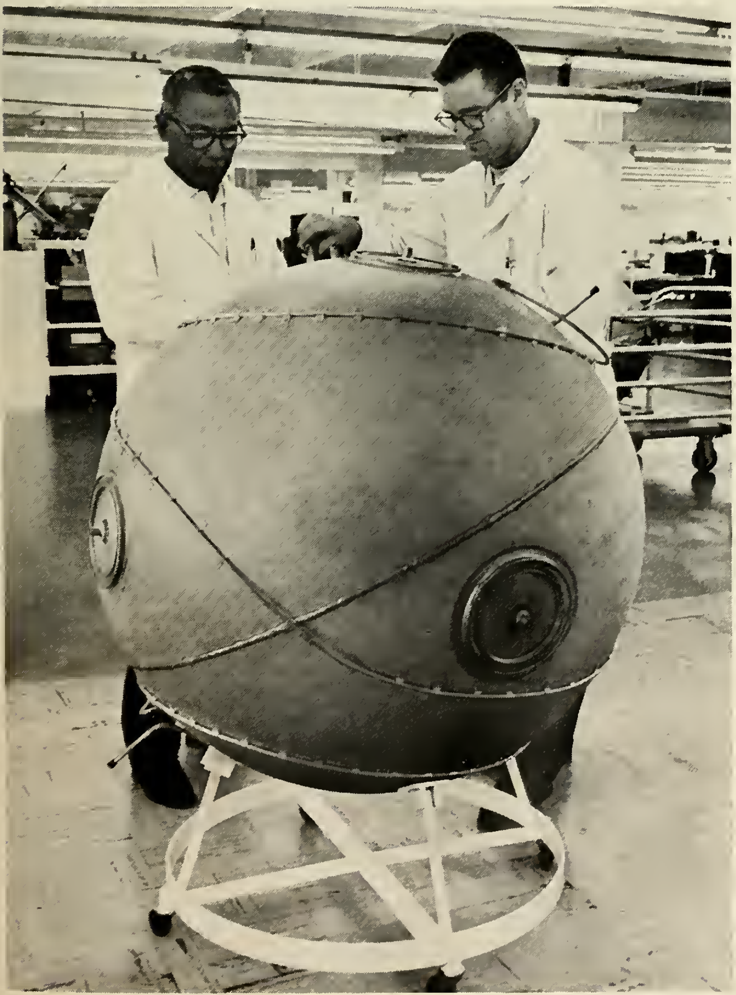

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Radar/Sonar Monitor Tested for Ships

Northrop developing test evaluation and monitoring system (TEAMS) under $7-million BuShips contract; general test procedure and format offer unit simplicity

by Rex Pay

Los Angeles—First of 26 test evaluation and monitoring systems (TEAMS) for 1052 class anti-submarine warfare destroyer escorts is undergoing pre-production tests before delivery to the Navy next fall.

Each system will continuously monitor the readiness of the long-range sonar system, fire-control radar, navigation radar, and air and search radar on each ship. TEAMS is similar to the DATICO automatic checkout systems monitoring *Polaris* readiness, but has all integrated circuits in the logic section.

The Bureau of Ships awarded a $7,323,000 contract for development and production of the TEAMS units for the destroyer escorts to the Nortronics Div. of Northrop Corporation last year. Work is due to start on the first production unit at the division's Anaheim facility late this month.

According to Donald R. Behrens of Nortronics, the most significant feature of TEAMS is use of a general test procedure and general test format. Repetition of these for every test of every system provides simplicity within the units.

TEAMS is intended to raise the performance of ship systems by rapid detection of deterioration or malfunction. It scans the critical parameters of each monitored system at 15-min. intervals while that system is operating. When a malfunction is detected, TEAMS checks back through the subsystems. It successively isolates the malfunction to smaller and smaller units of the system, tracing the cause of the defect.

The sequence of tests is thus dependent on the test results and on pyramid test diagrams that indicate information flow.

Two methods—There are two modes of operation, automatic and semi-automatic. In the latter mode, a test is selected manually and carried out automatically.

In the automatic mode, a binary-coded punched tape commands the sequence of automatic measurements to be made on the ship's electronic systems. Results are displayed as "go," "pass," or "no go," and are also printed out with an indication of the tolerance to which the measurements were made. "Pass" indicates a degraded condition, but still usable.

All control of tests is provided by a central processor equipped with a stored program. All input, output, control, measurement and evaluation is carried out in this processor. To make this possible, each system that is monitored is equipped with a unit that provides the necessary signal selection, signal conditioning, and test stimuli. When the central processor selects one of these remote units, it receives back a repetitive pulse train whose frequency indicates the scalar value of the measured item.

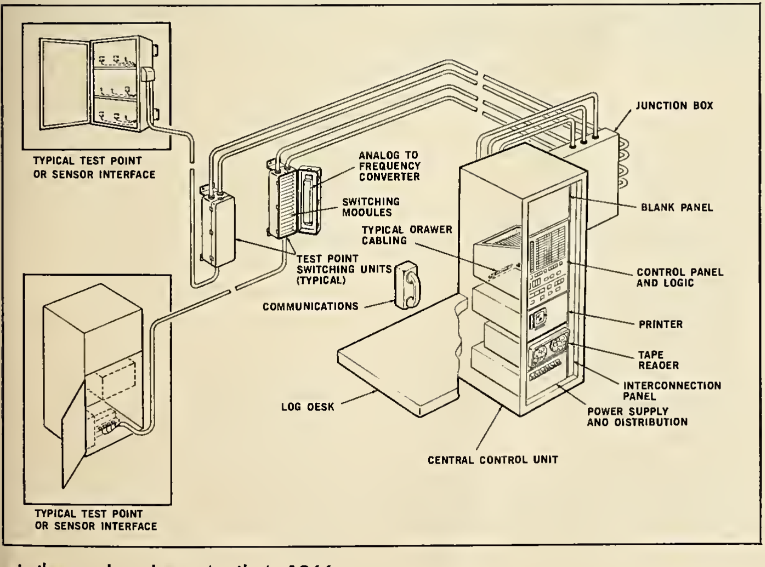
TEAMS may have up to 10 remote stations, with a maximum test-point switching capability of 500 selections at each station. Up to 19 additional stimuli or control functions may be handled for each remote station. Measurements that can be made by the system are frequency, period, voltage (dc, ac, peak, peak-to-peak), and current (dc or ac, indirectly as voltage). Ranges are 10 millivolts to 500 volts, up to 1 mc in frequency and up to 1 million microsec.

A status panel indicates which system is under test, and a number indicates the specific test. Measurements are read out in normalized form, centered on a nominal value of 1,000. Comparison limits are expressed as a percentage of nominal. When results are not being printed out, measurements proceed at the rate of six per second. The speed is halved with printout.

Testing sequence—To perform any test, the equipment goes sequentially through every step in the general test procedure; where a step is not needed, it is by-passed and the next step executed immediately.

The very minimum test involves specification of the test number, measurement type, measurement range, measurement factor, one set of no go limits, a normalized measurement and a no go comparison. Test complexity increases

Diagram shows Northrop Nortronics' test evaluation and monitoring system (TEAMS) which will be used to check out sonar and radar systems aboard ASW destroyer escorts. Delivery to Navy scheduled for next fall.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with addition of more test points, use of simultaneous and time-separated stimuli and measurements, and variations in the types of input and output devices involved.

The measurement technique makes use of a counter in the central processor. Any analog voltage to be measured in the system under test is selected by a switching module and routed to an analog-to-frequency converter. The repetition rate at the output of this is proportional to the input voltage.

The incoming pulse rate from the remote module is counted for a pre-computed duration within the central processor. If the analog signal at the test point is at its nominal value, the duration of the count in the central processor is such that 1,000 pulses will be recorded. An absolute readout option is also available to the operator. When he selects this, the count time is fixed so that the absolute value is displayed.

Continuous self-verification is carried out by TEAMS, based on parity checking. An additional self-checking program is available for fault diagnosis in the central processor itself. ■

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space electronics

New Product of the Week:

Ion Pump System

GENERAL ELECTRIC

A triode ion pump high-vacuum system for general laboratory use has been developed by General Electric Co.

Model 22SE020 can reach a pressure of 5 by 10^{-8} torr in 20 minutes and an ultimate pressure below 5 by 10^{-9} torr.

The bench-top unit can be converted into an ultra-high-vacuum system by the addition of a metal bell jar and bake-out facilities. Titanium sublimation pumps and quick-starting triode ion pumps with a speed of 50 liters per sec. are featured. The roughing pump, using LN_2 chiller molecular sieve material, provides micron level vacuums at which the triode pump and sublimation pump can start. An external cooling shroud with an air blower provides complete air circulation around the wall of the sump to enhance titanium pumping.

Glass bell jars of three different sizes can be used with the system. A wire mesh bell jar guard is provided as standard equipment. The system operates on standard laboratory single-phase power.

Circle No. 151 on Subscriber Service Card

Power Contactors

A series of interlocked double-throw power contractors for applications requiring positive load isolation has been developed by Leach Corp.

Model 9125 is rated 50 amps at the main contacts with an auxiliary contact rated at 5 amps. It will operate under such environmental conditions as 50 g's shock, vibration of 15 g's to 1,500 cycles, and temperatures from —70° to 125°C, the firm says.

Model 9324 has a 20-amp rating across the main contacts and no auxiliary contacts. It is said to withstand shock of 25 g's, vibration of 10 g's to 1,500 cycles, and temperatures from —70° to 125°C.

Both interlocked contactors are of balanced armature, double-throw construction, and are available with either a-c or d-c coil systems.

Circle No. 152 on Subscriber Service Card

Cathode Ray Tube

Du Mont Electron Tubes Div. of Fairchild Camera and Instrument Corp. has introduced a one-inch cathode ray tube for applications where compact size is required.

Model KC2437 has a usable face of

0.8-in. in diameter. Spot size is held to 0.007-in. Faceplate of the tube is made of optically-treated glass coated with a blemish-free phosphor.

Beam acceleration employs relatively low voltages, which is said to enhance deflection sensitivity.

Circle No. 153 on Subscriber Service Card

Signal Monitor

A special-purpose oscilloscope designed for use by personnel inexperienced in systems setup and trouble shooting has been announced by ITI Electronics, Inc.

The Type IT-273 test-point signal monitor features a 10-position test selector on the front panel that is preset to select specific horizonal sweep speeds, vertical gain and spot position. Setup and trouble shooting data for the system involved show the proper trace pattern for each test point and representative defective trace patterns with corresponding corrective action required. One data terminal involving 200 test points can be set up and maintained by the instrument alone, the firm claims.

The display is a 3-in. rectangular CRT. An ambient light filter and edge-lit scale are featured, and standard vertical sensitivity is 6v dc per inch at a bandwidth of dc to 1 MHz. Greater vertical sensitivity can be obtained with decreased bandwidth, and an a-c calibration signal is provided.

Circle No. 154 on Subscriber Service Card

Double-Plug Diodes

Texas Instruments, Inc., has announced availability of general-purpose diodes in subminiature configurations.

Designated IN456-IN459, IN461-IN464, and IN482-IN485, the glass-passivated silicon mesa devices are constructed in the Uni/GTM double-plug package. The whiskerless construction provides protection against shock and

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MARINE ENGINEERS and NAVAL ARCHITECTS—for work in Turbo-Power and Marine applications.

CHEMICAL ENGINEERS—for work in Combustion Analysis, Mechanical Components, Advanced Fuel Cell Development, Fuel Cell Performance Analysis, Fuel Cell Fabrication and Testing, Reformer work, and Heat Transfer.

METALLURGICAL ENGINEERS—for work in Advanced Structures and in the manufacturing and development of Fuel Cell Electrode Materials.

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Responsible for developing methods of relating cost to systems and sub-systems performance and physical characteristics. Positions involve development of quantitative costing techniques, such as cost models, for application to inter-system and intra-system studies, design trades, proposal evaluation and contract negotiations. Applicants should have demonstrable competence in cost model design and related quantitative technique.

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vibration, a company spokesman said.

Proven reliability is claimed in all environments up to 200-mw power dissipation at 25°C free-air temperature and low I_R at elevated temperatures.

Circle No. 155 on Subscriber Service Card

Integrated Circuit Module

A line of flip-flops with 30 fan-out from all sources has been announced by Computer Logic Corp.

The JK-31 plug-in module card contains 5 universal flip-flops, using DTL logic in dc to 5-mc design. The module operates from 0° to 70°C.

Typical noise rejection at any input is 0.9v. Up to 4-v noise can be superimposed on any JK output without affecting it. Each flip-flop in the unit has two J-steering inputs. Three of the flip-flops have two K-steering inputs. All can be preset or reset on a d-c basis, the company said.

Circle No. 156 on Subscriber Service Card

Ocean Temperature Probe

A digital oceanographic probe for measuring ocean temperature and temperature fluctuation at depths to 10,000 ft. has been announced by Gulton Industries.

The Model MET-2 has accuracy of ±0.01°C with temperature measurement of any liquid from —5° to 40°C. The thermometer has a two-wire system, capable of handling signal and d-c power on the same pair of conductors. Output may be picked up anywhere along the d-c power line between two decoupling units.

Circle No. 157 on Subscriber Service Card

Nitrogen Laser

A 50-kilowatt, ultraviolet, pulsed nitrogen laser has been developed by Avco Everett Research Laboratory.

The laser uses commercial-grade nitrogen to produce self-terminating pulses lasting 10 to 20 µsecs, with a variable repetition rate of 1 to 10 pps. Output wavelength is 3,370 Angstroms; output bandwidth is less than 1 Angstrom.

Beam divergence is 1 milliradian in ⅛-in. dimension and 10 milliradians in 1⅛-in. dimension. Power requirements are 2 ma at 20 kv.

Circle No. 158 on Subscriber Service Card

Frequency-Voltage Unit

Pioneer Magnetics, Inc., is marketing a continuously adjustable frequency-to-voltage converter with an expandable scale.

Model PM 1300-75 magacycler converter offers scale expansions from 1/1 to 50/1.

Linearity is better than 0.1% of full-scale frequency with 0.025% available. Output voltage varies from 0 to 10v dc; input frequency varies from the center frequency to the upper range setting. Output current is 0 to 20 milliamps; output impedance of less than 0.2 ohms.

Ambient zero and gain drift is very low, and the unit has temperature sensitivities of 0.001% of full scale/°C available. A temperature range of —50° to 72°C is possible. The unit accepts input signals from 10 mv to 20v. Plug-in frequency rangeboards give full-scale frequencies from 15 cps to 100 kc.

Circle No. 159 on Subscriber Service Card

Shipboard Recorder

A data recording system for use aboard ships and submarines has been announced by the Controls Div. of Leach Corp.

The MTR-4200 (AN/UNQ-8) system will record minute variations in the typical sound spectrum picked up by hydrophones. It will provide better than 55-db broadband S/N and better than 75-db single cycle S/N performance.

The unit will record and/or reproduce seven channels of direct or FM data. Through high-gain amplifiers, it will record a full range of signals as low as 400 mv without degradation of the signal to noise ratio, the firm says.

A low-mass, servo-controlled capstan drive system is phase-locked to the tape on reproduce and referenced to a precise frequency recorded on one tract of the tape.

Power consumption of the instrument is 350 w. The system will withstand environmental conditions specified by MIL-I-983, MIL-S-275 and MIL-S-901.

Circle No. 160 on Subscriber Service Card

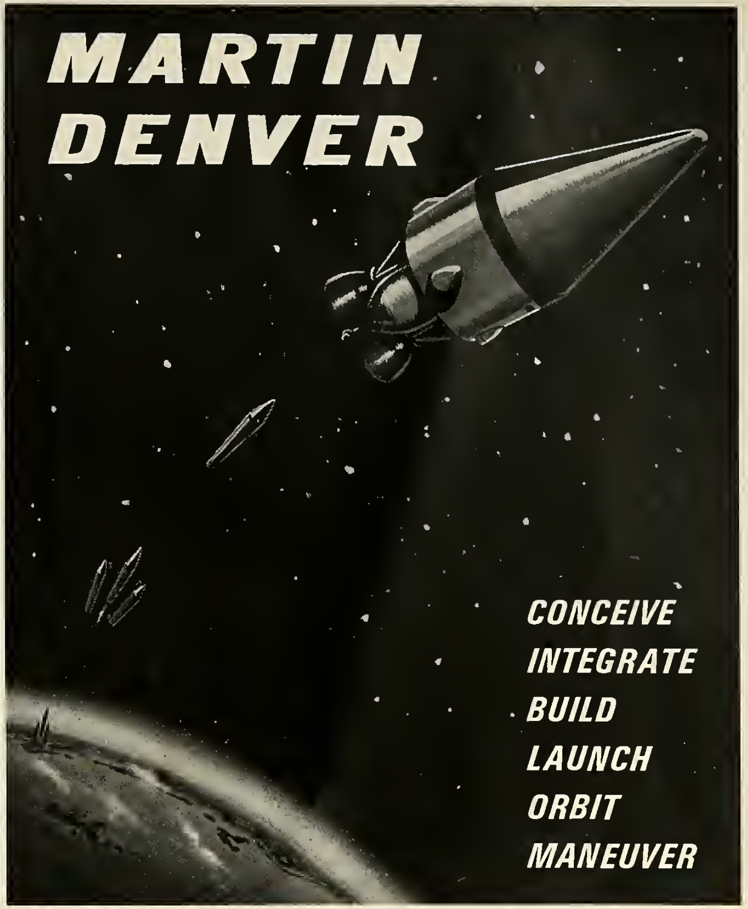
Waveguide Isolators

A series of water-cooled, high-power waveguide isolators for microwave systems use has been introduced by E & M Laboratories.

The Model X896HI is rated at 1-kw-cw power when terminated in a load VSWR of 1.5 maximum. Flow rate of 0.5 gallon per minute is required.

Frequency range is 8.5 to 9.6 gc with isolation of 20 db minimum. Insertion loss is 0.5 db maximum and bilateral VSWR, 1.10 maximum.

Circle No. 161 on Subscriber Service Card



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The Industry Week

California Aerospace Activity on Rise

Activity in the California aerospace and defense industries will rise during 1966, Gov. Edmund Brown has predicted. In his economic report to the California state legislature, Brown noted that employment reversed a two-year decline in mid-1965. The electrical equipment and aircraft industries showed an employment gain of 12,000 from December, 1964, to December, 1965. The instrument sector increased 6.5% and ordnance employment rose 4.1% for the period. If current trends continue, the report said, aerospace/defense employment for 1966 "should average well over 500,000, compared with the 1965 average of 481,300." DOD contracts are forecast at $5.6 billion; NASA awards are expected to total between $2.21 and $2.5 billion during the year.

New Activities

Omnitec Corp. has been established in Phoenix, Ariz., to build a new line of advanced products for military and aerospace applications. Harvey M. Ross, formerly marketing director for Motorola, Inc.'s Military Electronics Div., Western Center, is president of the new company. According to Ross, the corporate complex will grow through acquisition of existing companies. Projections call for a business of more than $30 million annual volume within five years, Ross said. Omnitec is a multiple-disciplined, technical organization and will do the greatest volume of its business in combining technologies, he said. . . . *Honeywell, Inc., Minneapolis, has renamed two divisions within its Industrial Products Group. The Philadelphia Div. has been designated the Industrial Div.; Honeywell's Denver Div. has been renamed the Test Instruments Div.* . . . Ampex Corp., Redwood City, Calif., has formed two new product divisions from the former Video and Instrumentation Div. The new Audio/Video Communications Div. will be managed by Thomas E. Davis, formerly vice president of marketing. The new Instrumentation Div. will be managed by Robert J. Weismann, former vice president of marketing. . . . *Environmental Control Systems, Long Island City, N.Y., has installed new facilities and services for dip brazing and fabricating aluminum components and assemblies. Capabilities of the $250,000 installation include planning, design, and consultation services. ECS is a division of the Pall Corp.*

Mergers and Acquisitions

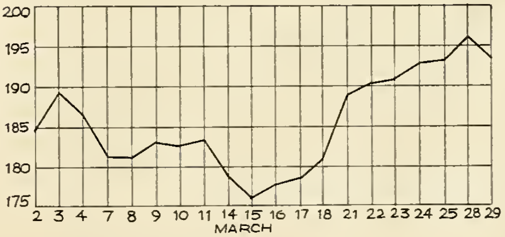
Honeywell, Inc., Minneapolis, will acquire the assets of Computer Control Co., Inc., Framingham, Mass., under a recent agreement by the two firms. One share of Honeywell common stock will be exchanged for each 3½ shares of Computer Control stock. The transaction is valued at about $29 million. Terms of the merger must be approved by directors of both firms and shareholders of Computer Control. . . . *TRW Metals Div., Minerva, Ohio, will move into facilities of the Bonney Forge & Tool Co., Alliance, Ohio. The plant will be used to produce components and assemblies for space and aircraft industries.* . . . Amphenol Corp., Broadview, Ill., plans to purchase the assets of Liberty Copper and Wire Co., Downers Grove, Ill. Liberty will be operated as part of the Amphenol Cable Div. . . . *Hurletron-Whittier, Inc., Whittier, Calif., a subsidiary of Hurletron, Inc., has been acquired by Giannini Institute, Duarte, Calif.*

International

Varian Associates, Palo Alto, Calif., has formed a firm in Copenhagen, Denmark, as a joint enterprise with two Danish firms—Hoffman and Sons and The East Asiatic Co. The new firm, A/S Radest, will provide irradiation services to Northern European industries. . . . *Hamilton Standard Div. of United Aircraft Corp. has purchased under license a new British electronic control technique from Hawker Siddeley Dynamics, Ltd. Under the agreement, UAC will have the right to use Hawker Siddeley patents covering the new electronic pulse system.* . . . Motorola, Inc.'s Semiconductor Products Div. will build a 60,000-sq.-ft. structure near Toulouse, France, for production of a full line of semiconductor devices. Operations are scheduled to begin in late 1967. . . . *Calbiochem, Los Angeles, has received an Atomic Energy Commission license to export a radioisotope to East Germany. The firm will ship 0.5 millicurie of carbon 14 tagged compounds to Isocommerz GmbH. It will be used by the Martin-Luther University in Halle in nucleic acid research.*

Missile/Space Stock Index

The Missile/Space Weighted Stock Index soared to record heights with a recovery in the general market as well as events peculiar to the defense/space field. These included a number of financial analyses of individual companies, several very large contracts, news that the Congress is dealing lightly with the space budget, and activity in the supersonic transport area. At 196, the Index represents almost a doubling of prices in the 19 companies involved since December 31, 1964.



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

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Port Hueneme, California 93041 / Department 011-MR-3

contracts

AIR FORCE

$1,000,000—Hughes Aircraft Co., Fullerton, Calif., to examine operational requirements of the proposed 407L tactical air operations center.

$304,230—Texas Instruments, Inc., Science Services Div., Dallas, for modification and test of 19 ocean-bottom seismographs.

$300,000—Dow Chemical Co., Midland, Mich., for high-energy propellant ingredient research. Also, $300,000 for supply of a high-energy solid propellant fuel and $146,124 to study kinetics of decomposition of solid oxidizers.

$197,174—TRW, Inc., Systems Group, Redondo Beach, Calif., for a study of aspects of ground environment, advanced mobile ICBM systems.

$159,211—Avco Corp., Research and Advanced Development Div., Wilmington, Mass., for updating specification of program definition phase for Mark 17 re-entry vehicle program.

$100,000—General Electric Co., Missile & Space Div., Philadelphia, for R&D of Mark 12 penetration aids system.

$48,250—General Electric Co., Missile & Space Div., Philadelphia, for research leading to design of low angular degradation prismatic reflectors for use in satellite geodesy experimentation.

ARMY

$12,700,000—Lockheed Aircraft Corp., Los Angeles, for engineering development of an advanced armed helicopter, to be capable of speeds over 215 mph, and armed with anti-tank rockets, grenade launchers and other armament.

$1,800,000—Beech Aircraft Corp., Wichita, Kan., for additional *Cardinal* target missiles.

$1,500,000—General Electric Co., West Lynn, Mass., for production of engines to support the Advanced Aerial Fire Support System.

$1,143,650—Varian Associates, Eimac Div., Palo Alto, Calif., for high-power microwave tubes.

$987,391—Allied-Wehh, Southgate, Calif., for *Titan III* site preparation at Vandenberg AFB, Calif.

$245,283—Philco Corp., Aeronutronic Div., Newport Beach, Calif., for *Shillelagh* missile repair parts.

$59,500—Research Magnetic Systems, Concord, Calif., for beam handling system.

NAVY

$13,100,000—General Telephone & Electronics Corp., Mountain View, Calif., initial funding of $26,200,000 contract for electronic equipment.

$3,515,224—Plymouth Industrial Products, Sheboygan, Wisc., for 2.75-in. rocket components.

$504,021—Cook Electric Co., Morton Grove, Ill., for R&D required to evaluate the susceptibility of designated Bureau of Naval Weapons radar system and guided missile fuze systems to countermeasures.

$375,243—Dynamics Research Corp., Stoneham, Mass., for *Polaris* inertial component and guidance system data collection analysis.

$349,891—Westinghouse Electric Corp., Baltimore, for a research program to maintain design cognizance and project direction over the Mk 45 mods 0 and 1 torpedos.

$106,000—Servo Corp. of America, Hicksville, N.Y., for dead-reckoning tracer test sets.

$90,650—Philco Corp., Aeronutronic Div., Newport Beach, Calif., for R&D on a technique to electronically control laser beams.

$57,763—Arde Portland, Inc., Paramus, N.J., for design and development of a single-axis swivel nozzle.

NASA

$909,090—Radiation, Inc., Melbourne, Fla., from Goddard Space Flight Center for *Nimbus B* PCM subsystem.

$550,000—American Machine and Foundry Co., York Div., York, Pa., from Kennedy Space Center for hardware and engineering services for crawler transporters.

$410,000—Canoga Electronics Corp., Chatsworth, Calif., from Goddard Space Flight Center for automatic tracking telemetry systems.

$269,883—Fairchild Camera & Instrument Corp., from Goddard Space Flight Center for *Apollo* monitor systems.

$134,047—TRW, Inc., Redondo Beach, Calif., from Lewis Research Center for research on ion beam diagnostics and neutralization.

$113,000—Westinghouse Electric Corp., Astronuclear Lab., Pittsburgh, from Marshall Space Flight Center for self-contained electron beam welding device.

$94,470—Systems Sciences Corp., Falls Church, Va., from Headquarters for analysis of communication and navigation satellite system concepts.

$92,183—Lockheed Aircraft Corp., Missiles & Space Co., Sunnyvale, Calif., from Lewis Research Center for *Agena/Nimbus B*/SNAP 19 hazard study.

$82,856—Keco Industries, Cincinnati, Ohio, from Kennedy Space Center for crew compartment cooling unit for Lunar Excursion Module.

INDUSTRY

$3,000,000—General Precision Equipment Corp., Kearfott Div., Little Falls. N.J., from **Goodyear Aerospace Corp.,** Akron, Ohio, for additional inertial-guidance platforms and associated electronic gear for the Navy.

$2,000,000—Garrett Corp., AiResearch Manufacturing Co., Los Angeles, from **Goodyear Aerospace Corp.,** Akron, Ohio, for *Subroc* control and auxiliary power supply systems.

$550,000—Allied Engineering Co., Southgate, Calif., from **Boeing Co.,** Seattle, Wash., for conversion kits for use in updating missile launch sites for the *Minuteman II.*

$500,000—C.&D. Batteries, Conshohocken, Pa., from **Boeing Co.,** Seattle, Wash., for storage batteries for advanced *Minuteman* ICBMs.

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WEEKDAY CHALLENGE / WEEKEND FUN

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names in the news

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William G. Sterns: Appointed vice president and director of engineering at Micro-Radionics, Inc. He will be responsible for all of the company's engineering activities.

Julian Hanft: Appointed manager of the reliability and maintainability section of Fairchild Space and Defense Systems, a division of Fairchild Camera and Instrument Corp. Prior to joining Fairchild, he was with Litton Industries.

James L. Farmer: Named manager of Army programs in Motorola, Inc.'s Military Electronics Div., marketing department. He joined Motorola in 1957.

Yura Arkus-Duntov: Elected to the board of directors of Pioneer Aerodynamic Systems, Inc. He is vice president of research for the Dreyfus Corp. and previously served in supervisory R&D capacities with the Curtiss-Wright Corp.

Jack E. Fadley: Appointed vice president for finance of Endevco Corp. He previously served as treasurer of the firm.

Jerome Ottmar: Elected to the board of directors of Norton Co. He is executive vice president of Textron, Inc.

John W. McDonald, Jr.: Elected president of McDonald Associates. **George R. Ufen** has been named vice president of the firm.

Raymond H. Hahn, Jr.: Appointed treasurer of the Fairchild Hiller Corp.

Edward J. Mack: Appointed director of research and development of the Dixon Corp. He was formerly with Allied Chemical Co.'s Plastic Div.

Wilbur A. Serwat: Named federal government marketing manager for Digitronics Corp. He previously worked for Control Data Corp. and Honeywell, Inc.

Alon Miller: Appointed manager of Planning Research Corp.'s electronic data processing systems department. He is also manager of San Diego, Calif., operations for the company.

Louis F. Heilig: Named assistant director of Philco Corp.'s Aeronutronic Div. tactical weapons program office. He was formerly chief engineer of Aeronutronic's tactical weapons systems.

Dr. George S. Benton: Appointed director of the Environmental Science Services Administration's (ESSA) Institutes for Environmental Research. ESSA was created as an agency of the Dept. of Commerce in 1965 to provide a single national focus to study man's environment and to meet the problems it presents.

Lawrence Sherman: Elected president of Whitney Metal Tool Co. He was executive vice president and has been with the company 25 years.

E. Finley Carter: Elected to the board of directors at URS Corp. He was president of Stanford Research Institute.

Milton K. Cummings: Re-elected chairman of the board of Information Sciences, Inc. He is president of Brown Engineering Co.

Bill Daniels: Elected to the board of directors of Information Handling Services, Inc. He is president of Daniels and Associates, Inc.

Donald E. Hare: Named assistant to the group vice president of military products at Norris-Thermador Corp. He was formerly vice president and works manager of General Fittings Co.

Robert J. Evers: Named as marketing representative and manager of the West Coast office of Dynamics Research Corp. He was sales engineer for advanced computer systems at North American Aviations, Inc.'s Autonetics Data Systems Div.

Emmet G. Cameron: Elected vice president of corporate development at Varian Associates. He will investigate fields of activity of potential interest to the company.

Jack C. Van Paddenburg: Named manager of the Los Angeles division of Computer Sciences Corp. He previously worked with the Aerospace Corp.

Gerhard R. Andlinger and **James V. Lester:** Elected vice presidents of International Telephone & Telegraph Corp. Andlinger will continue as group executive, Far East and Pacific, and as president of ITT Far East and Pacific, Inc. Lester is deputy group executive, technical industrial products; group general manager, controls, instruments and components; and president of ITT Controls and Instruments Div.

missiles and rockets
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APRIL

Rubber and Plastics Industries Conference, sponsored by the Institute of Electrical and Electronics Engineers, Sheraton-Mayflower Hotel, Akron, Ohio, April 4-5.

Conference on Exobiology, sponsored by the National Aeronautics and Space Administration and University of California Extension, Ames Research Center, Moffett Field, Calif., April 4-6.

Eighth Annual Symposium on Electron and Laser Beam Technology, sponsored by the University of Michigan, the Institute of Electrical and Electronics Engineers, University of Michigan, Ann Arbor, Mich., April 6-8.

Joint Meetings Aerospace Research Applications Center and the Indiana Executive Program, Indiana University, Bloomington, Ind., April 8-9.

Institute of Electrical and Electronics Engineers Region III Meeting, Atlanta, Ga., April 10-13.

Conference on Ground-Based Aeronomic Studies of the Lower Ionosphere, sponsored by the Air Force Cambridge Research Laboratories, Canadian Defense Research Telecommunications Establishment, Ottawa, Canada, April 11-15.

Symposium on Generalized Networks, sponsored by the Polytechnic Institute of Brooklyn, Hotel Commodore, New York City, April 12-14.

Fourth International Quantum Electronics Conference, sponsored by the American Institute of Physics, the Institute of Electrical and Electronics Engineers, Town House, Phoenix, Ariz., April 12-15.

Fourth Symposium on Remote Sensing of the Environment, sponsored by the Air Force Cambridge Research Laboratories, Office of Naval Research, University of Michigan, Ann Arbor, Mich, April 12-14.

Annual Technical Meeting and Equipment Exposition, sponsored by the Institute of Environmental Sciences, El Cortez Hotel, San Diego, Calif., April 13-15.

Second International Conference on Electron and Ion Beam Science and Technology, sponsored by the Electrochemical Society and the Institute of Metals Div., Park-Sheraton Hotel, New York City, April 17-20.

Annual Engineering Conference and Tool Exposition, sponsored by the American Society of Tool & Manufacturing Engineers, Statler and Sheraton-Cadillac Hotels, Detroit, April 18-22.

National Association of Corrosion Engineers 22nd Annual Conference and Corrosion Show, Fontainebleau, Miami, Fla., April 18-22.

Metals Engineering Conference, sponsored by the American Society of Mechanical Engineers, Sheraton-Cleveland, Cleveland, April 18-22.

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The Lessons of Vietnam—Part II

SAIGON

IT IS A BRUTAL TRUTH that for years the Dept. of Defense effort to apply available advanced technology to tactical combat problems has been woefully weak. The absurd fact that a nation which can control a spacecraft millions of miles away in space does not yet have a true standoff air-to-surface missile speaks for itself.

The capability was there and has been for some time; it was not pursued.

Let us look at the record. By the spring of 1943, the Germans had developed to the point where they were ready for combat use two tactical guided missiles—the P.C. 1400 FX radio-controlled missile and the Henschel Hs 293 glide-bomb.

The P.C. 1400 FX missile had an effect similar to that of a 3,000-lb. armor-piercing bomb and was specifically designed for use against heavily armored targets. It was successfully used on September 14, 1943, to sink the Italian battleship Roma, which was attempting to escape south of Sardinia to join the Allies.

German General of the Bombers Werner Baumbach, who was killed in a post-war crash in Argentina, described the Hs 293 in these words: "As soon as it was released it gained speed under rocket thrust, and went ahead of the parent plane. The observer used a control level to steer it up to the moment of impact. It was possible to employ this flying bomb in almost any tactical situation. The attack could be made from a distance of eight to nine miles from the target, i.e. out of range of anti-aircraft fire from the ship attacked."

The Hs 293 also was effective against bridges. In later improvements, the radio receiver was removed to prevent jamming and successful experiments were carried out in steering the Hs 293 by two trailing wires. A radar finder and a telescope eye were added.

In his book, The Life and Death of the Luftwaffe (Coward-McCann, New York, 1960), Baumbach credits the Hs 293 with a production rate of 300 a month and speaks of plans to increase this to 950. The weapon was never effectively deployed, apparently because of the confusion surrounding the entire German missile effort.

Any worthwhile work on tactical stand-off missiles died with the end of World War II.

During the Korean war, the Navy carried out an interesting experiment with guided drone aircraft as tunnel-busters. Crippled by an abortive censorship effort which attempted to portray these as true guided missiles, the project faded with the end of that conflict.

Now, 23 years after the Hs 293, U.S. aircraft in Vietnam are tailchasing a radio-command, visual-reference air-to-surface missile of 3-6 mi. range into target with every anti-aircraft weapon in the vicinity firing at them.

There are, to be sure, more effective standoff weapons in development, but descriptions of these are of little comfort to pilots fighting in Vietnam. The money which could have had them ready for use today was not spent.

IT IS NO NEWS to anyone familiar with the Vietnam war that aerial bombing tactics there are virtually identical with those of World War II and Korea. In the years since 1945, there has been no improvement to brag of in circular error probability (CEP) or the number of strikes required to knock out a particular target.

The need for anti-radiation missiles was brought home by the Cuban crisis, but the U.S. four years later still has no such weapon useful against SAM sites in North Vietnam. There are, of course, some in development.

The Navy has no bombardment missiles to support a Marine amphibious landing, hit enemy hardpoints along the coast or lob at a SAM site. There is no truly reliable missile to protect the fleet against air attack. There are, of course, some in development.

The Navy has only one nuclear-powered carrier, the Enterprise, which is proving its worth in combat in the South China Sea. The long-delayed second carrier has, of course, now been approved.

Blame for lack of standardization between Army and Air Force communications equipment can be laid directly at the door of DOD. Under the pressures of combat, the situation has been improved.

Use of microelectronics, common in the space industry for years, is conspicuous by its absence in Vietnam, where the technology is ideally suited to lighten the weight of combat equipment and improve its efficiency in hot-weather operations. Such equipment, of course, is being developed.

Infrared techniques for reconnaissance, used experimentally and effectively in Korea, suffered afterwards from lack of interest until Vietnam proved them vital.

It seems to have occurred to no one in the Pentagon that a contingency might arise in which B-52 bombers would be called upon to drop something other than nuclear ordnance—until Vietnam, when a major modification program was required before iron bombs could be used.

Men are being killed and wounded because their armor protection still is too light, although the technology exists to improve it. This would, of course, be expensive.

Forward air controllers, flying an aircraft which can't carry the load needed, are wondering when they are going to get the better aircraft which could have been available for them by now. It is, of course, in development.

It appears that Mr. McNamara and his Whiz Kids, for all their computers, programming and economy, have done precious little to improve the ability of U.S. forces to fight the enemy they face today—and that, after all, is why the Pentagon is there.

But then, of course, war is so damn expensive.

(Second of a series)

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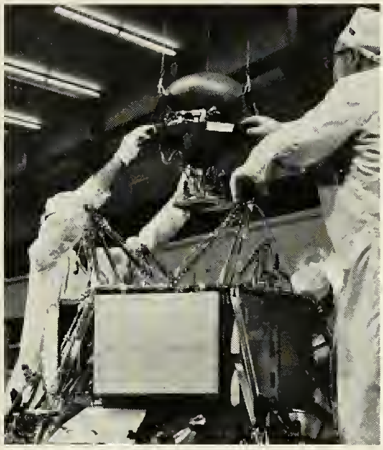
THE COVER

Scuba-diving engineer surfaces in new underwater facility at Westinghouse Research Laboratories, Pittsburgh, to be used in sonar research and underwater instrument testing (See p. 37).

48,100 copies this issue

What's up at JPL? Mariner IV!

(Among other things)


JPL engineers ready mid-course motor for Mariner IV

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and receives the historic photos of the Martian surface.

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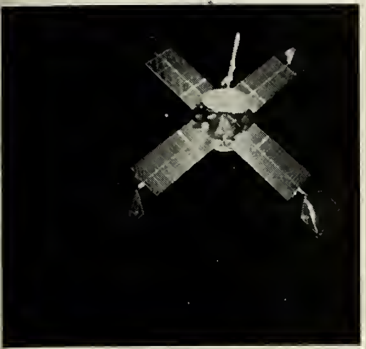

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Memo From Publishing Director

PUBLISHER BOUGHTON

One of the greatest pleasures of running a publishing house, or any business for that matter, is to see people grow in stature and ability to the extent that management can count on them for bigger and better things. Such is the case with the recent change at the publishing helm of MISSILES AND ROCKETS.

Alfred C. ("Ace") Boughton, the new publisher of M/R, joined the magazine in January, 1963, as National Sales Manager and has since that time exhibited the type of leadership, ingenuity and industry that made it easy for me personally to pass along the publisher's job.

Mr. Boughton came to M/R from McGraw-Hill, where he spent eight years as New England District Manager for *Aviation Week* Magazine. Prior to his involvement in the publishing business, he served in the U.S. Navy as an aviator following graduation from the Naval Academy in 1949.

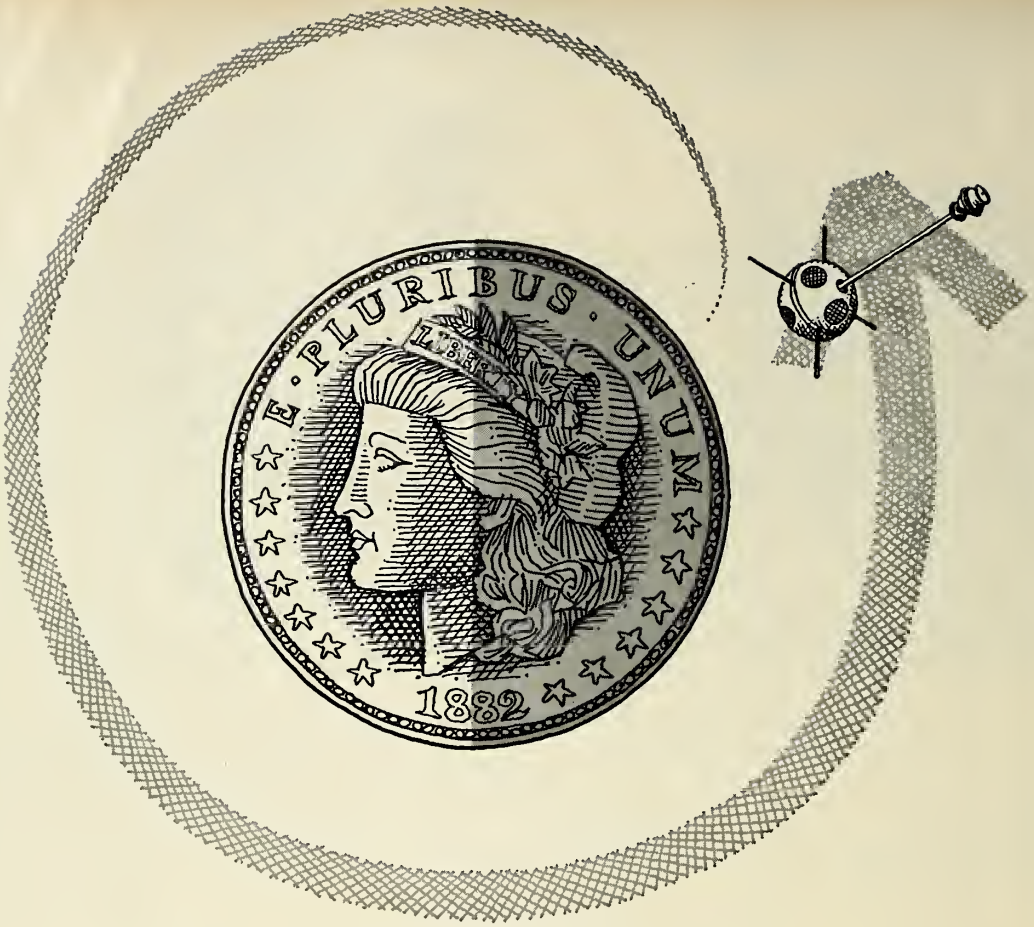
American Aviation Publications has grown considerably in the past few years, and with growth comes the opportunity for competent people to step into positions of increased responsibility. It is a pleasure to welcome "Ace" to his new post, and to the management team of AAP.

Another promotion which was announced recently by the Editor, Bill Coughlin, was the promotion of John F. Judge to the position of Senior Editor. John has been with the magazine for seven years, and has been one of the top authorities in Missile/Space materials and propulsion. I'm sure many of you have enjoyed John's articles over the years and join me in congratulating him on his promotion.

While I'm on the subject of plaudits, I'd like to publicly recognize the efforts of Editor Coughlin and Military Affairs Editor Mike Getler for their contributions to the Fifth Annual DOD Issue. Both men took personal risks far beyond what was necessary in order to give our readers a first-hand report on the applications of Advanced Technology in limited warfare. Their individual efforts, backed up by the hours of research and interviews of the remainder of the staff, produced what is quickly being acclaimed as the most outstanding issue in the history of MISSILES AND ROCKETS.

An extensive survey of many of our readers has convinced us that the advanced products and techniques developed in the Missile/Space field have already found useful applications in many areas. The DOD issue is an example of what you can expect from M/R's editorial staff in the future.

James Claar
PUBLISHING DIRECTOR



Long life in space is executive emphasis...

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MISSILE AND SPACE DIVISION

162-14

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The Countdown

WASHINGTON

Army Eyes British ET-316

U.S. Army says it is interested in the British *ET-316* surface-to-air missile and is continuing to monitor the program. However, there is no current intention to buy the weapon, Army sources tell COUNTDOWN. U.S. interest in the low-cost, fair-weather, TV-tracked missile was first reported in COUNTDOWN last year (M/R, June 14, p. 9; June 21, p. 17).

Webb European Trip Delayed

NASA Administrator James E. Webb will not go to Europe to explore plans for international space cooperation until Congress completes action on the Fiscal 1967 appropriation bill for his agency—probably in late May or June. An advance team of NASA officials already has visited four European countries inviting scientists there to propose projects for future cooperation. Webb will collect and discuss these proposals during his trip.

AF Plans Inland Minuteman Launch

Air Force hopes eventually to carry out a full-range test launching of an operational *Minuteman* missile from an inland silo. In March, 1965, a very short-range test was completed successfully from an operational *Minuteman* silo.

Apollo Pallet Reports Due

Written reports from four firms competing for the *Apollo* Experiment Pallet contract—Lockheed, McDonnell, Martin and Northrop—are due at NASA on April 22. Evaluation is expected to take several weeks before announcement of the contract winner.

New Navy Missile Is Also for Surface Use

Navy's new *Standard Missile,* designed primarily to protect the Fleet against an air threat, also is to be used as a surface-to-surface weapon against other ships. Disclosure of this previously unannounced capability came in a General Dynamics/Pomona report on a string of successful test firings at Naval Ordnance Test Station, China Lake, Calif.

Titan III-C Launch Set for June

Next launch of *Titan III-C* now is scheduled for the week of June 13, according to Air Force. The launch will carry the first round of military communications satellites into orbit in addition to a gravity-gradient stabilization experiment. The *Titan III-C* has been plagued in its last two flights with failures late in the flight sequence. Air Force says only minor engineering modifications have been made to meet the problems.

Chaparral Follow-On May Come Next Year

Army study of a possible follow-on missile to *Chaparral* to be used in large numbers by field units is due for completion this Fall. If a decision is made in favor of a new weapon, industry probably will be asked for proposals next Spring.

Cut-off Switch Added to Gemini 9

A central switch to turn off electrical power to the Orbital Attitude and Maneuvering System (OAMS) thrustors in a single stroke has been added to the *Gemini 9* cockpit. In event of a stuck thrustor such as encountered by *Gemini 8*, the crew can immediately interrupt electrical power between the bus and the circuit breakers before the spacecraft can build up excessively high attitude rates. After opening the circuit breakers, the crew then can return electrical power in an individual check of the thrustors. *Gemini 9* is to be electrically mated to its *Titan II* booster this week.

OAO Faces Possible Long Delay

Failure to achieve a successful launch this week may mean a delay of up to five months for the *Orbiting Astronomical Observatory*. If major work or recalibration is needed on *OAO* or its *Atlas* booster, the launch may have to be put off until the relative positions of the spacecraft in orbit and the stars it will seek are again favorable. Launch so far has been scrubbed five times because of unfavorable weather or problems with the *Atlas.*

INDUSTRY

Martin Gets Money to Improve Pershing

Martin-Orlando has another $14.5 million from the Army for initial development of new and improved airborne components for the *Pershing* missile system. The division recently was awarded $41 million to improve *Pershing* ground support equipment.

NAA Gets Condor Award

Navy is conducting negotiations with North American Aviation's Columbus Div. for engineering development of the *Condor* TV-guided, long-range air-to-surface stand-off missile. Initial effort is believed to be worth about $3 million and the total program is expected to cost hundreds of millions of dollars. Air Force buy of the missile is likely.

Berry Up for Promotion

Dr. Charles A. Berry, the astronauts' physician, is expected to be named assistant director for medicine at NASA's Manned Spacecraft Center within a few weeks, establishing a fifth directorate reporting to MSC director Robert Gilruth.

INTERNATIONAL

Japan Announces NavSat Plan

Japan has announced a seven-year plan for launching of a navigational satellite in 1972. The satellite will be developed by the Transportation Ministry and the launch vehicle by the National Space Development Center.

ESRO Launches Seven Centaures

Seven French-built *Centaure* vehicles were successfully launched in February and March under sponsorship of the European Space Research Organization from a base at Andoyn, Norway. The *Centaures* carried experiments for study of polar auroras. ESRO is to launch six more U.S. and French sounding rockets from the Eubea island base on May 20th to study an eclipse of the Sun.

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The Missile/Space Week

Teller Urges Missile Defense

Dr. Edward Teller, internationally known physicist and one of the principal developers of the hydrogen bomb, has once again urged that the United States proceed full speed with development and deployment of the *Nike-X* anti-missile missile system.

Appearing at the Third International Arms Control Symposium at the University of Pennsylvania and St. Joseph's College, held April 3, Teller said that a few years ago many experts, including himself, questioned the feasibility of a missile defense system. Today, however, he said that there is general agreement that such a system is practical. He emphasized two reasons why he favors full development of the system.

"One is that it can protect our retaliatory forces and our cities to the extent that a second strike force will function even if released with a proper delay. . . . also, the system can be developed into an enterprise that will protect not only us but our NATO allies as well."

Richard B. Foster, Stanford Research Institute, generally agreed with Teller but observed that "Ballistic missile defense is not a simple affair. The rate of deployment need not be abrupt but should be gradual. Initially, a light attack area defense could be deployed at low cost against attacks such as the Red Chinese might mount, or accidental or unauthorized Soviet attacks."

In the CBS television program, "Face the Nation," April 3, Teller also said that "everyone must defend himself, and these defensive weapons must be launched by the person who defends his own people and it cannot be done otherwise."

'Big-Q' Missile Design Flight-Tested by Air Force

First photo of the Air Force's "Big-Q" air-to-air missile shape which has been undergoing flight tests at the Air Force Weapons Laboratory, Kirtland AFB, N.M. Air Force officers have thus far described the vehicle as one of a number of shapes which are being developed to test new missile aircraft mating characteristics. It is not an active weapons development program, according to the Air Force.

NASA Names New Astronauts

Nineteen new astronauts have been selected by NASA to bring the total in the space pilot corps to 50.

The new group includes four civilians, seven Air Force officers, six Navy officers and two Marine Corps officers. They will report to the space agency early next month to begin training.

The new Air Force astronauts are: Capt. Charles M. Duke, Jr., 30, Edwards AFB, Calif.; Capt. Joe H. Engle, 33, Edwards AFB, Calif.; Maj. Edward G. Givens, Jr., 36, Manned Spacecraft Center; Maj. James B. Irwin, 35, Air Defense Command Headquarters, Colorado Springs, Colo.; Maj. William R. Pogue, 36, Edwards AFB, Calif.; Capt. Stuart A. Roosa, 32, Edwards AFB, Calif.; and Capt. Alfred M. Worden, 34, Edwards AFB, Calif.

Navy astronauts named include: Lt. John S. Bull, 31, Naval Air Station, Patuxent River, Md.; Lt. Cmdr. Ronald E. Evans, 32, on sea duty in the Pacific; Lt. Thomas K. Mattingly, 30, Edwards AFB, Calif.; Lt. Bruce McCandless II, 28, Stanford University; Cmdr. Edgar D. Mitchell, 35, Edwards AFB, Calif., and Lt. Cmdr. Paul J. Weitz, 33, squadron operations officer.

Marine Corps astronauts are Maj. Gerald P. Carr, 33, Marine Corps Air Facility, Santa Ana, Calif., and Capt. Jack R. Lousma, 30, Marine Air Station, Cherry Point, N.C.

Civilian astronauts include: Vance D. Brand, 34, Lockheed Aircraft Corp.; Fred W. Haise, Jr., 32, Flight Research Center; Dr. Don L. Lind, 35, Goddard Space Flight Center, and John L. Swigert, Jr., 34, North American Aviation, Inc.

Space Power Unit To Be Built

The Atomic Energy Commission has awarded Westinghouse Electric Corp. a $1-million contract to develop a modular thermoelectric power unit for space use.

Several prototype units were built under an earlier feasibility contract and tested for "hundreds of hours," Westinghouse has reported. Cylindrical in shape, the unit is described as about 2 in. in diameter and 20 in. long.

Ultimate aim of the program is to

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develop a tubular thermoelectric module that can withstand the rigors of space and provide power to run communications and other systems on either manned or unmanned vehicles. The module will use heat from a SNAP generator, Westinghouse said, or a radioisotope for conversion to electricity; it will be coupled to the heat-producer by electrical or hydraulic means.

Shots of the Week

The *Luna 10* spacecraft, launched by the Soviets on March 31, was placed into a near-lunar orbit on April 2 (see p. 13).

- The Air Force successfully fired a *Titan II* ICBM from Vandenberg AFB, Calif., on April 5.
- A *Minuteman* ICBM was fired April 4 by a Strategic Air Command missile crew at Vandenberg AFB, Calif. The Air Force launched another *Minuteman* from Cape Kennedy on April 1.
- A *Polaris A-3* missile was fired March 31 from the submarine George Washington, submerged off the coast of Cape Kennedy.
- Two *Athena* test missiles were successfully launched March 31 from White Sands Missile Range's Green River, Utah, test complex. The reentry vehicles impacted downrange.
- The Soviet Union placed the *Cosmos 114* scientific satellite in orbit on April 6.
- NASA successfully launched a rocket carrying 91 lbs. of instruments from Wallops Island, Va., April 6. Maximum altitude attained was 108 mi.; type of launch vehicle used was not disclosed. Two more launches were scheduled for April 7 and 8. Purpose of the flights is to compare techniques for studying the ionosphere.

Last Coupling Contract Let

The Naval Research Laboratory, Boeing Co., Lehigh University and Carnegie Institute of Technology will share a three-year, $3.9-million coupling contract from the Advanced Research Projects Agency on stress corrosion of cracking metals.

The ARPA coupling concept ties research capability, facilities and personnel from industry, government and universities together into a complex designed to attack general materials research problems.

The stress corrosion work breaks down into $1.2 million for NRL in-house research and $1.4 million for Boeing in-house work. Lehigh and Carnegie will each receive $720,000.

NRL, program manager, may add to the research complex using Navy funds and possibly including one member of the losing group of bidders. The other complex bidding for the stress corrosion work included Air Force Materials Laboratory, Lockheed-Georgia Co., Georgia Institute of Technology and Ohio State University.

MSFC Renews Service Pacts

Marshall Space Flight Center has renewed nine support-service contracts for a total cost of $61 million.

The one-year cost-plus-incentive-fee contracts are for maintenance of seven laboratories and three offices and cover work of some 4,500 contractor personnel in performing engineering, fabrication and institutional support.

Firms involved are Sperry Rand, Vitro Corp., Brown Engineering, Spaco, Inc., Northrop Corp., Hayes International Corp., Management Services, Inc., Rust Engineering Co., and RCA Service Co.

NERVA Test Goals Outlined

Increased specific impulse is one of the major goals in the program to develop nuclear engines for space, according to Harold Finger, manager of the joint AEC-NASA Space Nuclear Propulsion Office.

Speaking before the Aviation/Space Writers Assn. in Washington, D.C., April 4, Finger also set forth three other goals for the nuclear-engine program: increased operating temperature, increased power, and longer operational life.

Finger indicated that the only problem in the just-completed NERVA system test, designated NRX-EST, was with an actuator that controlled the amount of hydrogen going to the turbopump. The device was found faulty after two start-ups of NRX-EST in February. After several redesigns, the problem was corrected and the engine was successfully started nine times, using different control modes.

Turning to a large nuclear-engine flight stage, for which development money is included in next year's budget, Finger said he felt that the decision can be made today to use this modular concept for post-*Apollo* applications even though post-*Apollo* decisions have not been made.

Applications might include use with a *Saturn V* for lunar landing or, in clusters or singly, for manned planetary fly-bys or landing. Finger pointed out, however, that he doesn't anticipate use of nuclear stages for landing operations due to contamination problems. Rather, the nuclear stages would be left in orbit.

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SENSOR SYSTEMS — Scientists and engineers are now needed to conduct theoretical and experimental programs on advanced radar and optical detection and tracking systems. Work includes advanced radar systems planning, design and analysis with emphasis on radar signal design, signal processing, parameter estimation, target radar characteristics, and radar coverage. Basic studies are to be conducted of sensor systems and sub-systems with focus on receiver techniques, spectrum analysis, delay-line techniques, signal processing, pulse compressors, MT and HF propagation.

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New ICBM Program Taking Shape

Michael Getler

WASHINGTON—A wide-ranging Dept. of Defense effort to design a new and vastly improved intercontinental range ballistic missile will be completed this fall.

This will permit DOD to make a decision on development of the new weapon, called the *Improved Capability Missile* (*ICM*), in time for possible funding in the Fiscal Year 1968 budget.

The missile could be operational by 1973 at the earliest, high-level DOD officials told MISSILES AND ROCKETS. While its inclusion in the FY '68 budget is not certain, officials state that "at some point the project will move ahead."

Exact configuration of *ICM* remains the subject of numerous design and trade-off studies now under way by DOD, the Air Force and industry; however, the basic intent is clear.

Steps forward—The missile will be larger and more expensive than the new *Minuteman III* (M/R, Jan. 31, p. 15). It will carry at least twice the *Minuteman* payload, M/R was told, over roughly the same distance—estimated to be about 7,000 mi. The payload will include both an improved array of penetration aids and a larger warhead.

The *ICM* will carry multiple warheads and will be maneuverable during the re-entry phase in response to preprogrammed commands based upon the anticipated level of enemy defenses.

If approved, the program is expected to cost "a couple of billion dollars," according to high-level officials.

ICM will probably replace a portion of the 1,000-missile *Minuteman II* and *III* mixed force, or be added to it; a factor largely dependent upon the most up-to-date analysis of the offensive threat facing the U.S. at the time, the state of enemy missile defenses, and an evaluation of the best way to preserve the capability for assured destruction of the enemy.

Several concepts are being studied for *ICM*, including both fixed and mobile missiles, and hot and cold launch techniques. The mobile versions under study reportedly include both rail- and vehicle-transported missiles. Another option being looked at involves the old "pill in the box" problem, where missiles could be moved around between widely separated fixed silos, thereby complicating an enemy targeting problem at any given time.

The *ICM* will also be even harder, in terms of resistance to nuclear effects, than is *Minuteman*, say officials, either through mobility or refinements to silos. Among the trade-offs under consideration is whether or not *ICM* could be mated with modified versions of existing *Minuteman* silos. While this may turn out to be feasible, officials say that other potential improvements—such as the ability to introduce much additional hardness, "something we now know much more about"—may argue for building new installations.

Hard-point defense seen—Whatever configuration is chosen, if the program moves to fruition *ICM* will be a very expensive and very powerful new weapon. If it is deployed in fixed sites, one high-level official told M/R, it is almost certain to trigger the development of a hard-point missile defense system to protect it.

The question of protecting ICBM sites with defensive missiles to insure their survival against enemy missile attack (beyond the protection offered by hardening the site) is intimately tied to the question of cost. With relatively inexpensive ICBM's, such as *Minuteman*, it may be less costly to continue adding to the existing force, thereby increasing an enemy's target list, than to build an anti-missile system to defend certain numbers of them.

The U.S. is pressing forward, with considerable success thus far, in experimental programs aimed at achieving an effective hard-point defense capability at a cost which will make it competitive with the costs associated with simply adding more ICBM's (M/R, March 14, p. 15).

While the *Minuteman* force "is also probably worth protecting" in the future, according to DOD experts, the size, expense and strategic value of an *ICM* provide a much more clear-cut case of a missile force which is definitely worth protecting with a point-defense missile system.

There are at least two point-defense systems now being looked at for this role. One is the HIBEX/HAPDAR experimental high-acceleration booster and phased-array radar program (M/R, Mar. 14, p. 15), and the other involves use of the *Sprint* terminal-defense missile already developed as part of the *Nike-X* area-defense anti-ballistic missile program. Though *Sprint* may appear more expensive in this role, officials say that on a one-to-one ratio, the longer-range and high-performance *Sprint* could probably protect many more silos.

Soviet defense concern—The *Improved Capability Missile, Minuteman III*, and the accelerated development of the Navy's *Poseidon* submarine-launched missile (M/R, Jan. 31, p. 16), all represent attempts by DOD and the services to introduce even greater capabilities into offensive missiles to penetrate Soviet defenses.

Recent reports from Moscow (M/R, Apr. 4, p. 7) indicate that what are believed to be large radars associated with an anti-missile missile system have been sighted in the countryside surrounding Moscow and Leningrad. While DOD officials maintain silence on these reports, the subject is highly sensitive and is known to be causing considerable concern in DOD and the Air Force, and an increasingly lively pace in the development of penaids.

One official told M/R that the U.S. response to any verified Soviet ABM system would more than likely involve "making sure we can penetrate it" rather than building an ABM in this country to counteract any such Soviet system.

This statement probably reflects the prevailing view in the top levels of DOD regarding the future of *Nike-X*. While component development continues with the aim of meeting a threat at all levels, deployment attention has turned sharply away from the Soviet threat and toward that posed by the Chinese Communists.

There are several well-known reasons for this. DOD feels that it is im-

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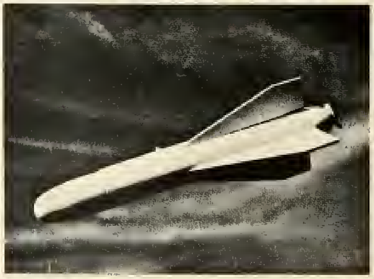
First Photo of Walleye

First photo of a model of the Navy's Walleye TV-guided glide bomb which will be produced by the Martin Co.'s Orlando Div. The weapon, which is anxiously awaited in Vietnam, is also expected to enter Air Force inventories.



possible that even the best missile defense system can offer anywhere near complete protection against a large and sophisticated enemy missile force, such as that of the USSR. Hence, the $20-billion *Nike-X* system has never been able to make its way to the top as the most cost-effective way of limiting damage to the U.S. when put up against the Soviet threat. Deterrence through a large, survivable missile force equipped with advanced penetration aids remains the cornerstone of U.S. defensive policy vis-à-vis the Soviets.

On the other hand, the emergence of the Chinese nuclear capability in the past 18 months—coupled with major improvements to *Nike-X*—a longer-range area-defense missile enabling exatmospheric intercept—continued progress in the *Sprint* terminal-phase intercept missile program for protecting large point targets, and reduced radar costs associated with new modular designs—has made a far less expensive light-attack version of *Nike-X*, tagged with a high kill probability against the Chinese, unquestionably realistic.

Nike-X "will come"—"Because of the possibility of this different kind of deployment," one high-level official told M/R, "people have now focused on this (the Chinese threat) rather than the other (the Soviet threat)."

"Ultimately," he states, "*Nike-X* will come. But whether or not it will be in FY '68 is not yet clear." He also believes that the program will not get started outside of the normal budget cycle unless some startling new intelligence is uncovered.

Adding to what is now described as a "bullish" atmosphere concerning a future go-ahead for a light-attack version of *Nike-X* was the testimony released last week of Secretary of Defense Robert S. McNamara before the Congressional Joint Committee on Atomic Energy.

"Even though we have spent $2 billion to develop an anti-ballistic missile system, McNamara told the committee, "and have under development the most advanced form of such defense that exists in the world today, it is not capable of defending this nation against a sophisticated attack. . . ."

However, McNamara quickly added that "*Nike-X* can defend the nation against the type of attack that Communist China might direct against us in the 1975-85 period."

As an example of the kind of assault a non-sophisticated attacker, such as China, might launch which could be handled by *Nike-X* in some configuration, McNamara cited one including a relatively small number of warheads, about 100, or even "a larger number" if they do not contain decoys. ■

Orbiting of Soviets' Luna 10 Widens USSR Lead to Moon

WASHINGTON—The Soviet Union's *Luna 10* spacecraft has beaten the U.S. by at least four months in becoming the first satellite to orbit the Moon.

At the same time, U.S. officials expect the Russians to attempt more flights in lunar orbit and a possible landing on the surface.

Together with soft-landing *Luna 9* on the lunar surface on Feb. 2, the latest Soviet feat means that the USSR has passed two major space obstacles prior to attempting to land men on the Moon.

This country's first *Surveyor* spacecraft—which is scheduled to soft-land on the Moon—will not be launched until late May or early June. U.S. scientists see very little chance of success on the first try, which means the first American soft touchdown could be delayed until this fall or even later.

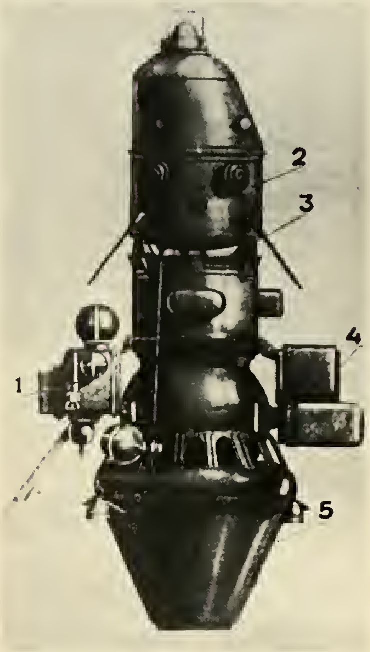
U.S. try in July—*Lunar Orbiter*, the U.S. spacecraft designed to orbit the Moon and take photos and transmit data back to Earth, will not be launched until late July or August. This program has proceeded on schedule thus far and there appears to be a good chance for success on the first try. Even if it is successful, however, it will still be at least four months behind the Russian feat.

U.S. officials and scientists were at a loss to explain why the Russian craft did not carry a camera system to photograph wide areas of the Moon. It is estimated that the total surface could be photographed during a 28-day orbital mission.

One possible reason is that the Russians chose to send a fairly cheap spacecraft on the first mission to accurately determine meteorite shower hazards and the Moon's gravitational pull. Later, when they are sure of the orbital parameters required for a successful mission, it is believed the Russians will launch a spacecraft equipped with a camera system.

Politics involved—Political expedience may be another answer. The Russians were hard-pressed to pull off a space spectacular during the 23rd Congress of the Soviet Communist Party.

Luna 10, which conspicuously played the Communist Party's Internationale to the packed Congress, was probably designed as a quick and cheap way of filling that need.



A drawing of the Luna 10 spacecraft, released by Tass, shows 1) measuring radio-system equipment; 2) instrument capsule; 3) capsule separation system; 4) guidance system and 5) rocket propulsion system.

Dr. Edward C. Welsh, secretary of the White House's National Aeronautics and Space Council, said that the guess as to why the Russians did not have a camera on board is that they put up as sophisticated a system as they could and still meet the deadline into getting it into lunar orbit first while the Congress was in progress. "The prestige apparently was more important to them than getting a camera on board."

Mission details—*Luna 10* was launched on its epic voyage on March 31. The 540-lb. spacecraft, according to Russian reports, was first placed in Earth orbit.

Then *Luna 10* station and its rockets, with a combined weight of about 3,530 lbs., started toward the Moon at a speed slightly under 7 miles a second. The flight trajectory was corrected on April 2 by radio signal; as the craft neared the Moon, its velocity was slowed by retro rockets. Russian press reports said that *Luna 10* was put into orbit at a speed of eight-tenths of a mile per second on April 3. ■

New Apollo/Saturn Schedule May Delay First Manned Flight

Hal Taylor

WASHINGTON—NASA has delayed the launch of its second unmanned *Apollo* spacecraft for two months.

This could mean that there will be no manned flight in the three-man spacecraft this year.

Word of the slippage was learned as the space agency announced it had decided to change the sequence of its two upcoming *Saturn IB* launches (M/R, March 21, p. 12).

The space agency said that the *Apollo/Saturn-202* mission has been rescheduled to follow the *AS-203* mission, with both launches slated for the third quarter. The change was made to permit additional checkout of the *AS-202* spacecraft, NASA said.

Informed sources report that *AS-203* is set for July with *AS-204* to follow in August. NASA's original schedule called for *AS-202* to go in June, with *AS-203* in July.

The two-month slip in the *AS-202* flight reportedly is caused by late delivery of the spacecraft.

Mission objectives—*AS-203* is a launch vehicle development mission and will not carry an *Apollo* spacecraft. It is an early test of the *Saturn V* third stage and is intended to verify that the orbital operational features of the liquid-hydrogen propulsion system are satisfactory.

The *AS-202* mission will be the second flight of an unmanned *Apollo* spacecraft; the first one (*AS-201*) was successfully launched Feb. 26. *AS-202* will verify performance of the *Saturn IB*, the *Apollo* spacecraft Command and Service Modules and the heat shield.

The two flights will be launched from two different launch pads at Cape Kennedy—*AS-202* from Complex 34 and *AS-203* from Complex 37. This lends little credibility to NASA's theory that changing the sequence will provide additional time for spacecraft checkout.

Informed sources reported that the spacecraft for the *AS-202* mission was supposed to have been delivered to the Manned Spacecraft Center by North American Aviation, Inc., Space and Information Systems Div. in February. A check with NASA Headquarters last week, however, revealed that it still had not been delivered. Officials said delivery was expected early this month.

AS-204 schedule—At the same time, it was learned that the spacecraft for the *AS-204* mission—expected to be the first manned flight if *AS-202* and *AS-203* are successful—is scheduled to be delivered in June. Officials said it was still too early to know whether it will be delivered on time.

Even if it is delivered on time, it's still possible that NASA will not meet the planned November date for the first manned flight. The two-month slippage in *AS-202* means that the agency will have two months less to check out data from the flight before committing three astronauts to the first manned flight.

In addition, if some technical problem develops during *AS-202*, NASA will have less time to find a fix. This would probably put the first manned flight off until 1967.

"Super Guppy"—Marshall Space Flight Center shipped the *Saturn IB* second stage for the *AS-203* mission April 5 from Sacramento aboard the "Super Guppy" aircraft. S-IVB flight stages are built by Douglas Aircraft Co. at Huntington Beach, Calif., and tested at the Sacramento Test Center. The Super Guppy arrived at Cape Kennedy April 6.

Booster stage for the *Saturn IB* launch vehicle was scheduled to leave the Michoud Assembly Facility on April 7 aboard the NASA barge "Promise." Chrysler Corp. builds the boosters at the Michoud plant and tests them at Marshall. Promise is expected to arrive at Cape Kennedy about April 12.

A third major element of the next *Saturn IB* flight vehicle—the instrument unit—is scheduled to be flown to Kennedy Space Center April 13 aboard the Super Guppy. The instrument unit was assembled by IBM at its Huntsville plant.

A boilerplate nose cone will replace the *Apollo* spacecraft for this flight. The nose cone, manufactured by Marshall, has already been shipped to KSC by barge.

In another recent hardware movement last week, a laboratory model of the *Saturn* S-IVB rocket stage arrived April 2 at Marshall aboard the Super Guppy. The rocket stage, which is 58 ft. long and 21½ ft. in diameter, was flown from the Douglas Sacramento Test Center. The model will be used here in conjunction with similar models of other stages of the *Saturn V* launch vehicle in an extensive laboratory development and test program.

The Guppy aircraft is a modified B-377 stratocruiser, built and operated by Aero Spacelines, Inc., for transporting *Saturn* S-IVB stages and other large space hardware under a contract to NASA. ■

Martin Wins Re-Entry Vehicle Contest

MARTIN CO. has won the competition for development of the Piloted Low-Speed Test (PILOT) re-entry vehicle and is negotiating with the Air Force. Northrop Corp. had also been in contention for the award, which is valued at close to $1 million.

The award could give Martin an advantage for future development of a shuttle vehicle for the Air Force's *Manned Orbiting Laboratory* (*MOL*). PILOT is the third phase of the START (Spacecraft Technology and Advanced Re-entry Test) program, and is the first manned portion of the program. Martin is also responsible for the second portion of START, which is labeled PRIME for Precision Recovery Including Maneuvering Entry.

START is the overall name given to the program created to replace the *Dyna-Soar* effort, which was canceled in December, 1963. The program could move into the $100 million-plus category within the next few years, according to project sources.

The next portion of START, phase four, which would be based on Martin's PRIME and PILOT work, will be concerned with the development of a manned lifting-body vehicle for an orbiting spacecraft such as *MOL*. According to informed sources, the Air Force has not yet approved such a program.

PRIME will demonstrate the feasibility of maneuvering at hypersonic speeds. Four unmanned PRIME SV-5D lifting-body re-entry subscale vehicles will be launched from Vandenberg AFB, Calif., during 1966 and 1967 aboard *Atlas* boosters.

PILOT's SV-5P vehicle will be larger than SV-5D and may accommodate one or two men in a test of vehicle characteristics ranging from supersonic to transonic speeds. Dropped from B-52's, it would gain speeds of Mach 2 through the use of small rocket engines. PILOT will also be used to study control and stability during approach and landing.

Industry-Related Bills on Firing Line

WASHINGTON—Several bills of interest to the Missile/Space industry appear headed for some rough going when Congress reconvenes next week after a prolonged Easter vacation.

No date has been set for full Senate Judiciary Committee consideration of the McClellan patent bill, which has been reported out of the Patent Subcommittee. However, this bill faces a major battle on the Senate floor by Sen. Russell B. Long (D-La.) and others.

Crux of the argument is whether or not the Government should take title on patents which may arise out of inventions made during the execution of Government contracts.

The bill is one of several introduced in the past few years; among them it most closely follows the present regulation, which was issued in memorandum form by President John F. Kennedy on Oct. 10, 1963.

The McClellan bill (S1809) allows agency heads a great deal of flexibility in determining to whom patent rights should go—whether to the Government or to the contractor.

About the only absolute case it spells out in which the Government must take title deals with inventions which have a bearing on the public health. In other cases, it leaves it up to the administrators of the agencies to decide whether the Government should waive the patent. An example is cases in which inventions arise during Government contracts to which the contractor has brought previous experience and special capabilities.

Long and several other Senators have strongly opposed the bill, substituting a Long amendment which would require the Government to take title to all inventions and patents emerging from Federally financed research or performed by Federal employees.

NASA and DOD have supported the McClellan bill and strongly opposed the Long version. Language details proposed by the agencies in hearings last session have been taken into consideration by the subcommittee in reporting out the McClellan version.

Information bill—Another bill being lidded down by a full committee after approval by a subcommittee deals with Freedom of Information. Passed by the Senate last session, the measure awaits consideration by the full Government Operations Committee of the House, where opposition reportedly exists.

The bill would require agencies of the Federal Government to make their records available to the public, upon request, apart from a few exceptions such as national security. It would give to the public the right to go to court to get such information.

Among agencies directly affected would be the Defense Department and NASA. Among other criticisms leveled at these agencies during Senate hearings was an accusation that they have tended to trumpet their own praises and cover up mistakes.

Over 40 members of the House have added their sponsorship to the bill, which is identical to the Senate bill. However, White House opposition is said to be holding it up.

Republicans especially in recent days have begun to put pressure on the Administration. Rep. Robert P. Griffin (R-Mich.), ranking Republican on the Information Subcommittee which is headed by Rep. John Moss (D-Calif.), said that "if the Johnson Administration makes any further moves to weaken or block the passage . . . the bipartisan supporters of this vital legislation should take the issue to the people."

Systems engineering—A bill in each house would authorize the Secretary of Labor to give funds to the states in order that they may contract with education institutions, profit or non-profit corporations to do studies on the application of systems-engineering techniques to social and economic problems.

These problems could include such things as mass housing, transportation, juvenile delinquency and crime, information, waste disposal and the like, but would not be limited to these.

Bills submitted in the Senate by Sen. Gaylord Nelson (D-Wis.) and in the House by Rep. George Brown (D-Calif.) are resting in the Government Operations committees of the respective houses, with no plans as yet for hearings.

Metric bill—Still hanging fire in the House is a bill which would provide for a study of the feasibility of switching to the metric system in the United States.

The Senate has passed the measure and the House Science and Astronautics Committee has eschewed its own similar version in favor of the Senate version, hoping that it will become more attractive to the Rules Committee, which must pass on it before it can come to vote on the floor. Even so, it remains in limbo in that body.

R&D distribution—Another measure gaining support in the House is a resolution which would instruct the National Science Foundation to make a study of the available scientific resources in the country and devise a plan for a more equitable distribution of Federal spending on research and development.

While the resolution has not come to vote, some opposition is expected from within Government agencies in the R&D field. ■

NASA Procurement Reorganized

NASA HAS ESTABLISHED two new assistant director positions and two new divisions in its procurement office.

The major feature of the reorganization calls for grouping all divisions to report to the two new assistant directors, one for policy and review and one for contract management. The assistant directors in turn will report to George J. Vecchietti, Jr., still director of procurement.

Paul A. Barron, formerly assistant general counsel for regulations and general law, General Services Administration, has been named assistant director of the policy and review office. William F. Risso, who has been acting as special assistant to the director of procurement since October, 1965, has been named assistant director of the contract management office.

The newly created offices are the Procurement Surveys Div. and the Staff Operations Div. The former will report to the director of procurement and will be responsible for evaluating the effectiveness of procurement management at NASA field centers. It will be directed by Harvey M. Kennedy, Jr.

The Staff Operations Div. will also report to the director of procurement and assist in planning, coordinating, and directing the activities of the procurement office in administrative, statistical reporting and Congressional presentation areas. Chief will be Harold E. Pryor.

Zero Magnetic Field Achieved in Lab

William S. Beller

WASHINGTON—For the first time, researchers have produced a region in which the magnetic field is totally eliminated.

The work that went into this development is leading to a magnetometer several orders of magnitude better than any that exist today, a perfect gyroscope, and a check on the law of time reversal invariance.

Stanford University scientists detailed these findings to more than 150 Dept. of Defense officials attending the first Research Applications Conference. Sponsored by the Air Force's Office of Aerospace Research (OAR), the meetings were held in Washington, D.C., on April 5.

In another paper, an Air Force scientist outlined the significant amount of data an optical system could give about an orbiting spacecraft, and noted how inexpensive the method is.

Zero magnetic field—The Earth's magnetic field is exceedingly difficult to blank out in an experimental region. And the fact that the field varies with time adds to the problem. Thus far nobody has been able to balance out the Earth's field to better than 10^{-7} gauss, Stanford physicist William M. Fairbank told M/R. His conference paper, coauthored by William O. Hamilton and C. W. F. Everitt, was based on work supported in part by OAR's Office of Scientific Research. The Earth's magnetic field is about one-half gauss.

What changed the picture for the Stanford scientists was the experimental discovery in 1961 that the flux in a superconducting ring is quantized, that is, in a ring of a given size only certain magnetic fields can be trapped. This is analogous to the discrete energy states that electrons are restricted to in their orbits around nuclei. The flux quantum was found to be 2×10^{-7} gauss/cm^2.

This experimental work bore out the earlier prediction of physicist Fritz London that perhaps the electrons in a superconductor were locked together in their motion so that they collectively behaved as though they were in a single macroscopic quantum state.

B. S. Deaver and Fairbank hollowed a small tin cylinder about a thousandth of an inch in diameter within a larger cylinder and cooled it through the transition temperature into the superconducting state. The superconducting cylinder then acted as a magnetic shield, by the Meissner effect, trapping the internal flux and excluding the external flux. Importantly, the experimenters observed that "if the flux in the hole of the cylinder is less than half a flux unit no flux at all is trapped in the hole."

The experimenters also found that if more than half a flux quantum were trapped, the field in the hollow would be a full quantum, and so on, with always a quantum jump to the nearest number of unit quantums. Thus it is possible to construct a magnetic flux of as few quanta as desired, and a truly zero magnetic field inside a hollow superconducting shield "provided the shield is cooled through its transition temperature in a magnetic field sufficiently small that the total flux passing through the shield is less than half a flux unit," according to the experimenters.

The magnetic field can be reduced to 10^{-5} or 10^{-6} gauss by conventional shielding methods. Fairbank and his associates have found a practical way to reduce the field still further and yet have a reasonably large experimental volume to work in. The method calls for successive expansions of a flexible superconducting bladder made of a lead-coated Mylar. This bladder is folded as small as possible, and when made superconducting, will trap the flux within it. The bladder is then expanded, spreading out the trapped flux lines in the process and thereby decreasing the magnetic field by the ratio of the areas before and after the expansion.

If a second superconducting bladder, contained within the first, is then expanded, the field strength is decreased further. This process can be continued until the magnetic flux is reduced to less than half a flux unit and the trapped flux goes down to zero when the bladder becomes superconducting. An apparatus using this technique is now under construction at Stanford and will offer a permanent region of zero magnetic field for further experimentation.

Use of quantum fields—A magnetometer theoretically able to measure magnetic fields down to 10^{-11} gauss can be made and is a striking demonstration of the use of the theory of flux quantization in a superconducting cylinder. The 0.001-in.-dia. tin cylinder described earlier is arranged so it can be heated and cooled through its transition temperature at a frequency of 20,000 cps.

When the cylinder is cycled into the superconducting state, the flux is kept from the walls of the cylinder by the Meissner effect, and the flux within the cylinder goes to the nearest quantum flux. The Meissner effect in the walls of the cylinder, which gives the total value of the axial flux field, is measured by the output voltage across the terminals of a coil wrapped around the cylinder.

As the magnetic field is increased, periodic fluctuations in the signal reflect the periodic trapping of increasing integral units of quantized flux within the tin cylinder. From the cross section of the cylinder and the strength of the magnetic field, the flux quantum is measured. And the periodic variation in the quantum of flux gives an absolute-sensitive calibration of the change in the magnetic field.

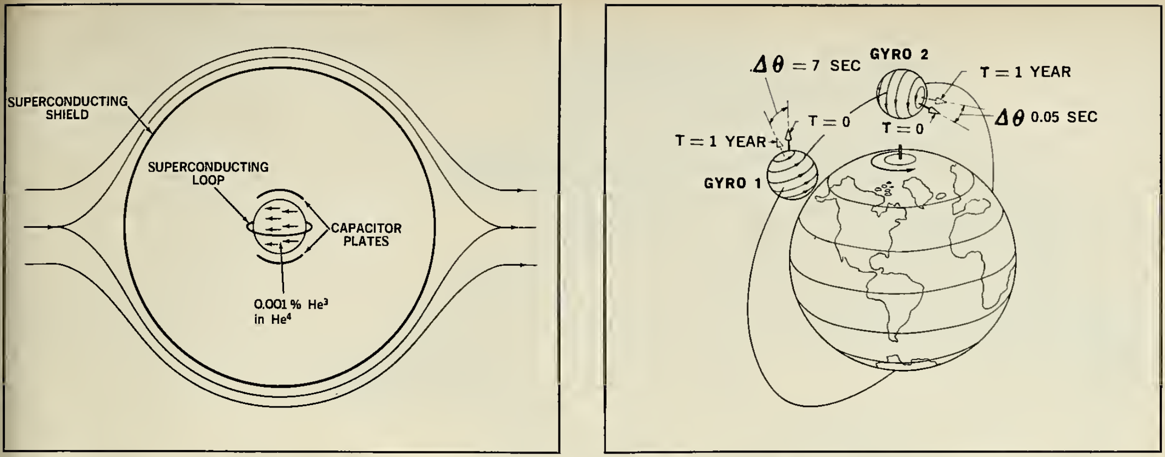
Use of zero field—The ability to maintain a zero magnetic field "opens the door to the free-precession nuclear gyroscope," Fairbank told M/R. Theoretically, this could be a perfect gyro which would be unaffected by all external torques. The nucleons of atoms would act as the miniature spinning masses.

Interest centers in the He^3 nucleus, composed of two protons and one neutron. In making a gyroscope of the He^3 nucleus, the external magnetic field must be reduced to zero. Otherwise, the nucleus would precess at the intolerable rate of 2×10^4 radians/gauss, about 3,000 revolutions a second in a one-gauss field, or half this in the Earth's magnetic field. This gyroscope is unaffected by acceleration or gravity and could have wide guidance application.

The He^3 nuclei are oriented by optical pumping so that they all spin in the same direction. However, thermal disorder in pure liquid He^3 will disorient the nuclei in about 500 seconds. To prevent this, Fairbank suggests forming a solution of one part of He^3 in 10^5 parts of He^4, which would have a relaxation time of more than a year.

A superconducting loop around the nuclear gyro would be used to detect the gyro's orientation. The technique is based on the fact that completely polarized He^3 nuclei of the desired concentration will produce a magnetic field of about 10^{-5} gauss along their axes of spin. Since the amount of flux from the He^3 nuclei passing through the loop depends on the relative orientation of the loop with respect to the direction of the magnetization of He^3, a measure of this flux will determine the relative orientation of the loop and the He^3.

Checking fundamental law—With the nuclear gyro, "a very exciting experiment in physics could be per-



LEFT: Schematic of free precession nuclear gyroscope. RIGHT: Relativistic precessions of gyroscopes in 500-mile polar orbit.

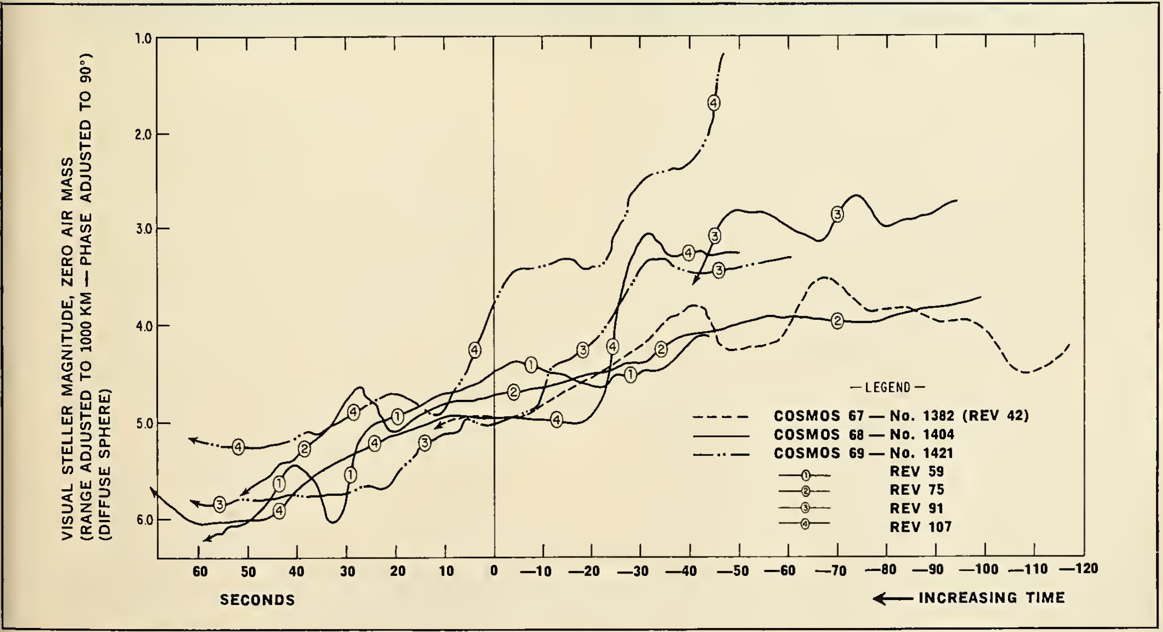
formed to see if the nuclei are really perfect gyros," says Fairbank. If, for instance, the positive and negative electric charges within a nucleon are slightly displaced with respect to each other, then an external electric field placed on the nucleus would cause it to precess. Thus, the nucleus would have demonstrated a permanent electric dipole moment and "would violate the principle of time reversal invariance which has been found to be valid in every previous experiment in physics except for a recent one at Princeton," says Fairbank.

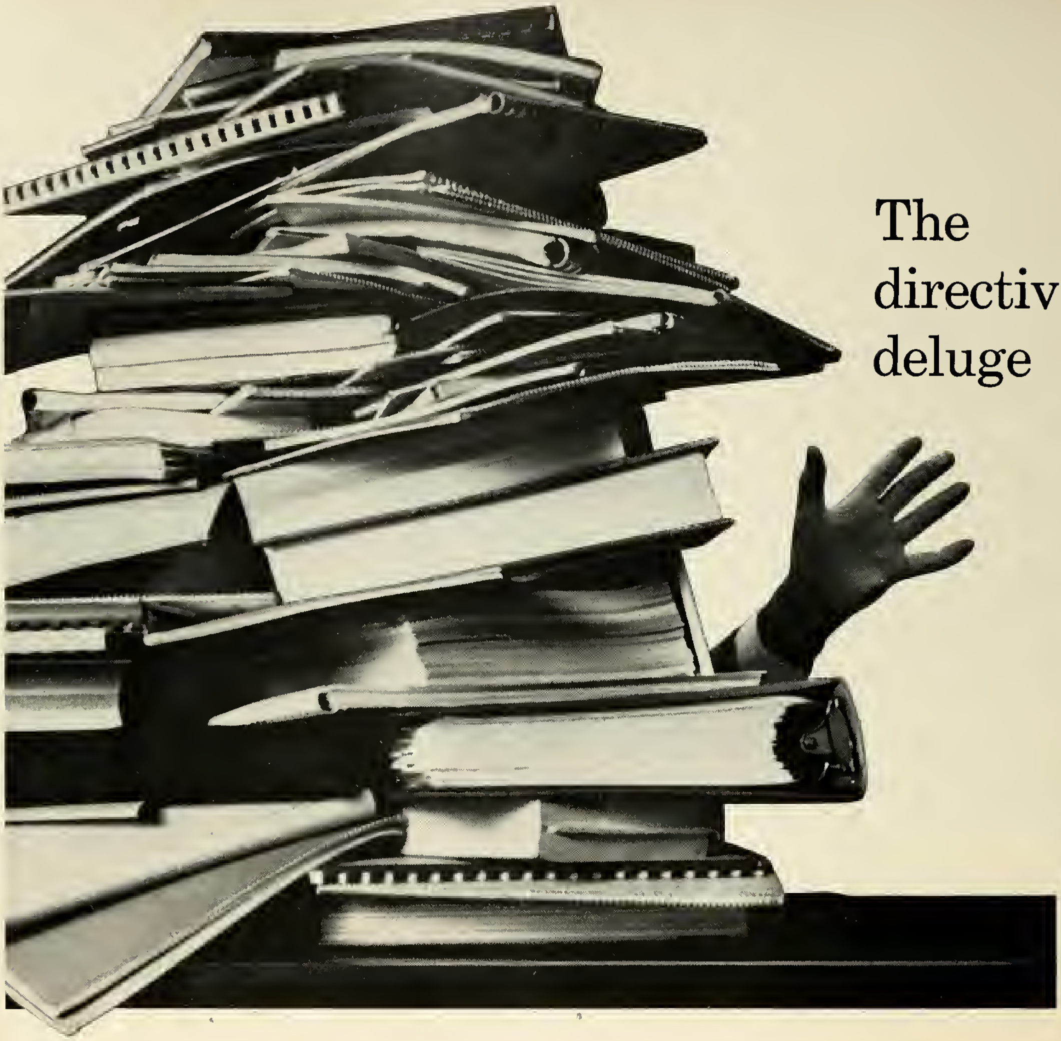
Checking Einstein's theory—Stanford scientist L. I. Schiff has calculated that a perfect gyroscope orbiting the Earth 15 times a day should precess seven seconds a year, based on Einstein's general theory of relativity. This would result from gravity effects. Moreover, because of the Earth's rotation, the gyroscope should precess 0.05 second of arc, and in a polar orbit these two precessions would be at right angles.

A highly accurate mechanical gyroscope will be constructed within the year to test the concept, and will probably fly in orbit within five years. The gyroscope will consist of a homogeneous quartz ball, 1.5-in. in dia. coated with a thin layer of niobium. It will be electrostatically supported and spun up in the superconducting state by helium gas spin-up jets. Since a spinning superconductor produces a small magnetic field along its axis of spin, this field will indicate the gyro's orientation with respect to the known position of a superconducting loop.

Spacecraft signatures—The light reflected from an orbiting spacecraft "contains very detailed information on its surface characteristics, surface finish, and dynamical motions," reports an Air Force scientist. Kenneth E. Kissell, Aerospace Research Laboratories, Wright-Patterson AFB, says that the technique would allow him to measure spin-axis orientation of selected targets, vehicle geometry, and vehicle size-albedo product. He adds that he has been able to classify vehicles by similarities in overall signature patterns, surface-finish (specular, diffuse paint or glossy paint), and surface protuberances. He suggests using the optical data as "a strong check, complimentary in character, to radar-determined data." ■

Comparison of photometric data from Cosmos satellites for a diffuse sphere model.





The directives deluge

Project managers in government agencies have directives to tell them what to do. They also have directives that tell them when to do it and where to do it. Then, for added information and guidance, there are financial directives, performance directives, test directives, reliability directives, evaluation directives, training directives, and maintenance directives. To name a few.

Yet, there is no how-to-get-the-job-done directive.

To the project manager with the problem of coordinating prime contractors, Vitro's value is the ability to provide objective technical support and make unbiased creative contributions to the overall cost effectiveness of the system. We have our own directive on this. Vitro policy states that we will not supply production hardware for any system on which we perform the engineering/coordination service. For information we direct you to Joseph C. Kinsey, Vitro Laboratories, 14000 Georgia Avenue, Silver Spring, Maryland, 301 942-7200.

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Technical Countdown

CONVENTIONAL ORDNANCE

2.75-in. Fuze Production Accelerated

In an apparent attempt to solve the current fuze shortage for 2.75-in. FFAR (folding fin aircraft rocket), the Dept. of Defense is now broadening both the industry-production and technological base. Six contractors are presently manufacturing both type-423 (helicopter use) and type-427 (aircraft use) fuzes. Following a recent Army solicitation, excluding present manufacturers, bids were received on April 1 for a new series of contracts to produce type-423 fuzes. Three contractors are expected to be selected soon for a crash program to help solve the Vietnam war fuze shortage. On April 4, bids were received by the Army's Harry Diamond Laboratories for engineering and development of a new 2.75-in. velocity-time (VT) fuze. Designed for VT arming, the electronic proximity fuze is expected to be employed with the relatively new rocket fragmentation head to further improve its efficiency as an anti-personnel weapon. Two firms will be selected to pursue a seven-month crash program.

20-mm Fuzes Rain-Tested

The Air Force Missile Development Center, Holloman AFB, N.M., is testing 20-mm high-velocity projectile fuzes on its rocket-powered sled track to determine the effect of rain on such units. In the program, being conducted for the Army, fuzes are installed on the forward end of a probe extending well in front of a 1,400-lb. sled. The sled, powered by a single *Nike* rocket booster, travels on a monorail at speeds up to 2,100 mph over a 35,000-ft. track. The actual test area is a 6,000-ft. portion of the track where fuzes are exposed to "rain erosion" from a double row of trackside nozzles pouring out water spray at 5,000 gallons per minute. The simulated rain reduces the vehicle speed to 1,000 mph. Very-high-speed image motion cameras are employed to record profile test data during the erosion process, and spot-velocity counters record a complete velocity profile of each test, the Air Force said.

ACOUSTICS

White Sands Explosion Due in May

The Atmospheric Sciences Office, Army Electronics Command, plans to explode two 40,000-lb. charges of TNT in May to study propagation modes of low-frequency acoustic energy. Two 20,000-lb. charges were detonated last November. Various laboratories concerned with nuclear weapons effects will be monitoring the low-frequency waves generated by the explosion. Transducers capable of responding to infrasonic waves are reported to be available. The detonation will take place in the northern part of White Sands Missile Range, N.M., Army sources said.

PROPULSION

Propulsion/Life Support System Proposed

NASA Lewis Research Center scientist J. Reece Roth has proposed that a propulsion life-support system be developed to provide crews with conventional food and water and also process metabolic wastes to fuel the electric rocket propulsion system. Ion engines could be built, he said, which could use carbon dioxide and water, while solid residues would be small enough to be stored or discarded. Weight savings from such an integrated system, Roth says, would be so great that, if necessary, a less efficient thrustor could be used with no overall loss in performance.

Zero-G Hg-Feed Ion Engine Under Way

Fabrication of a flight-type zero-g mercury-feed system for ion engines for interplanetary missions is now under way at Jet Propulsion Laboratory. Following evaluation of various materials for compatibility with mercury, a titanium tank with a diaphragm of neoprene rubber has been selected to provide a positive expulsion system with an inverting diaphragm in the storage tank and a porous matrix vaporizer. Storage capacity is 10,000 amp-hr. The vaporizer is a 3-in.-long, 3/8-in.-dia., 50%-dense, 316 stainless steel rod. The isolator is a boron nitride tube, 1¼ in. in diameter and 5 in. long. A wall thickness of 0.040 in. is used for the 4½-in. titanium pressurization tank. Use of the system with a modularized thrustor array is accomplished by insertion of a propellant manifold between the tanks and the vaporizers. Each vaporizer and isolator then becomes associated with an individual thrustor and can be controlled accordingly. The feed system requires 25 watts of power.

Lewis Gets RL-10 Responsibility

Lewis Research Center will take over project management of the RL-10 launch vehicle development project for NASA. The first U.S. hydrogen-fueled rocket engine, the RL-10 is employed as the *Centaur* upper-stage propulsion unit and has been used (in clusters of six) as the *Saturn I* (S-IV) stage while under the control of Marshall Space Flight Center. Completion of the project transfer is expected by mid-May, according to NASA officials. Pratt and Whitney Div. of United Aircraft Corp. is RL-10 prime contractor.

Super-High-Thrust Ion Engine Claimed

A multiple linear-strip, cesium-contact ion-engine design, claimed to exhibit the highest thrust density of any electro-static engine, has been developed at Hughes Research Laboratories. Medium-length life tests of about 1,000 hours were concluded successfully with tungsten ionizers. Improvement of high-work-function ionizers is expected to lead to engines with lives longer than all anticipated missions (over 100,000 hours). Work has concentrated on 4-strip and 13-strip engines, the latter producing thrusts of 21.8 millipounds at 6,000-sec. specific impulse. Use of a radioisotope source to heat the ionizers promises 95% electrical efficiency over the 4,000- to 10,000-sec. specific impulse range, report engine developers at Hughes. Unfortunately, reduction in program funding has prevented further engine development.

HUMAN FACTORS

Lunar Loafers Tested at NAA

Tests are under way at North American Aviation's Space and Information Systems Div. on "Weightless Restraint Sandals" developed by Hardman Tool & Engineering Co. for the *Apollo* program. The sandals are made of a moccasin-soft, royal-blue thermoplastic which encloses the ankle, and has a hook-and-pile material sole which will fasten astronauts to the floor of the *Apollo* capsule in weightlessness but still permit walking. The boots are buttressed inside with semirigid thermoplastic soles and ventilated with tiny holes.

Firm Seeks Bigger Beryllium Market

John F. Judge

San Diego, Calif.—Solar Div. of International Harvester Co. is aggressively expanding its fabrication of beryllium structures.

Earlier this year, a planning committee set up within the firm reviewed the entire beryllium field and concluded the potential was large enough to justify highly active participation. Facilities are being enlarged and the firm is pursuing a number of possible contract areas.

Solar is already well into two major efforts with the metal—the SNAP-27 radiator and a tube program with NASA's *Saturn* launch vehicle project.

The SNAP-27 work moved swiftly into high gear after an initial six-month materials feasibility program. SNAP-27 is a power unit package to be left on the lunar surface by the *Apollo* astronauts with the *Apollo* lunar surface experiment.

The generator will be fueled with Pu-238 to supply 50 watts over a 5-year lifetime. General Electric's Missile and Space Div., Valley Forge, Pa., is prime contractor for the Atomic Energy Commission program.

The radiator will be an all-beryllium cylinder with a diameter of 6 in. and a length of 24 in. A series of 6-in.-high beryllium fins coated for maximum emissivity will surround the basic cylinder.

All joints will be furnace-brazed using a silver brazing alloy. The joints will be hermetically sealed. Production radiators will be delivered to General Electric within 12 months.

Tube details—The beryllium tubes are structural members designed to support the thrust-vector-control system for the *Saturn 1B*. The tubes will be 130 in. long with a 5-in. outside diameter and a ⅛-in. wall thickness.

This is a structural materials research program—and only part of a larger NASA effort to conserve weight by substituting lighter-weight materials through the *Saturn* launch vehicle design.

The program is now in the hands of subcontractors—Berlyco for the tube sections and Ladish Co. for the forged end pieces. It is a long-lead-time item and once the tube sections and forgings reach Solar, the task of fabricating the structural member begins.

The load-bearing tube is an experiment in the technology of beryllium including stress analysis, design, fabrication and the development of test techniques to verify the entire process.

The tube sample will have a titanium/beryllium interface—adding even more complication to the problem.

Saturn/Apollo scope—Solar is one of the major fabricating subcontractors on the *Saturn V/Apollo* system. The firm is building lightweight antennas for both the *Apollo* spacecraft and the Lunar Excurison Module.

Bimetallic valves, liquid hydrogen, and LOX ducts and bellows, pressurization hardware, heat exchangers, instrument unit cold plates and ground support equipment components are all under contract.

Manufacturing problems often lead to research programs. In one case, the jacketed cryogenic ducting now specified for the *Saturn V* launch vehicle may be improved with weight savings by mating cryopumping technology to propellant feed lines.

Success in this area would lead to sealing these at atmospheric pressure instead of the current 10-micron vacuum level. This would yield direct benefits in weight reduction, elimination of field leak problems, possible elimination of vacuum level instrumentation and accompanying cost reductions and increases in reliability.

The duct work is under contract to Marshall Space Flight Center and complements other contracted research efforts on improving the liquid hydrogen flexible ducting technology.

R&D depth—Solar is inordinately strong in research and development for a subcontractor in the aerospace business. The firm has developed a reputation for working with the difficult materials over the past 25 years. This theme is still a characteristic of the division.

There are nine distinct laboratories, together with an advanced development shop that functions as a manufacturing methods operation as well as a pilot plant for specific customer orders.

The labs—all more or less materials oriented—cover metallurgy, chemistry, physics, processes, welding, reinforced plastics, high temperatures, powder metallurgy and advanced manufacturing technology.

The operating philosophy at Solar starts with identifying new materials in relation to their use in the industries covered by the firm's customers. Then research programs are initiated to understand the materials, learn to work with the available forms and then develop fabricating and joining procedures.

A case in point is the Solar process for bimetal joining. This is a fully developed production method for joining any aluminum alloy with a solidus temperature of 1,100° F or higher to most stainless steels and superalloys.

The essential elements of the patented process include conditioning the stainless steel and brazing it to the aluminum alloy. The process can handle joints up to 8 in. in diameter, but larger diameters can be accommodated should the need arise.

Joining processes are constantly under research at Solar—sometimes with outside funding. The firm has a contract with the Materials Lab at Wright-Patterson AFB to develop brazing alloys for beryllium and another with NASA to bond pyrolitic graphite to metals.

The latter program involves design configurations to overcome stress problems and the use of what Solar researchers refer to as "molecular anchor points."

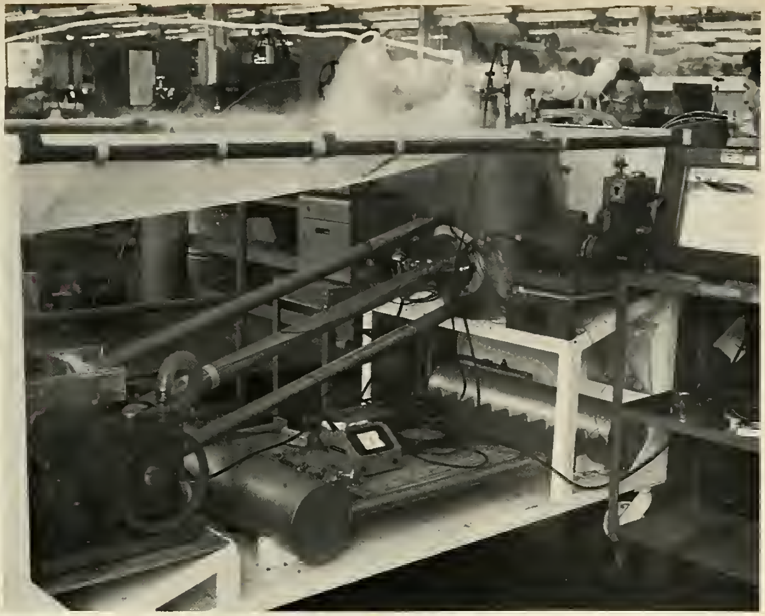
There are programs in developing resistance welding techniques to achieve diffusion bonding, and the joining of titanium foil by brazing and diffusion bonding.

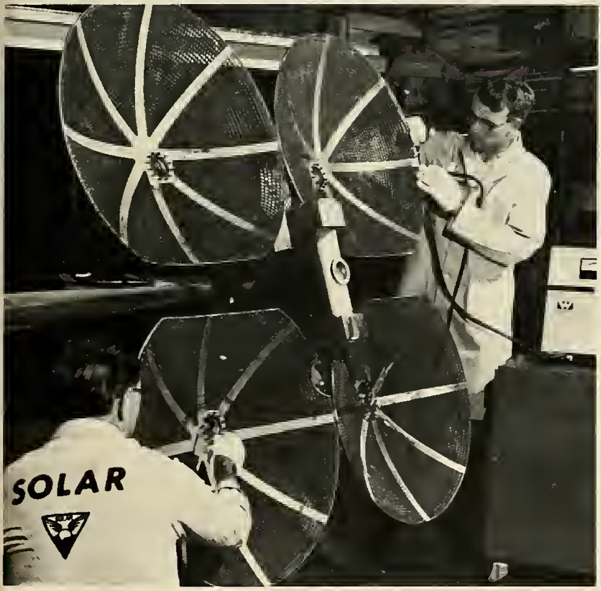
Sheet ability—Fabrication of foil materials is a strong technology at Solar. Nuclear fuel racks and aircraft components have been produced for years. Research in thin-gage materials covers both cryogenic areas and temperatures up to 5,000° F.

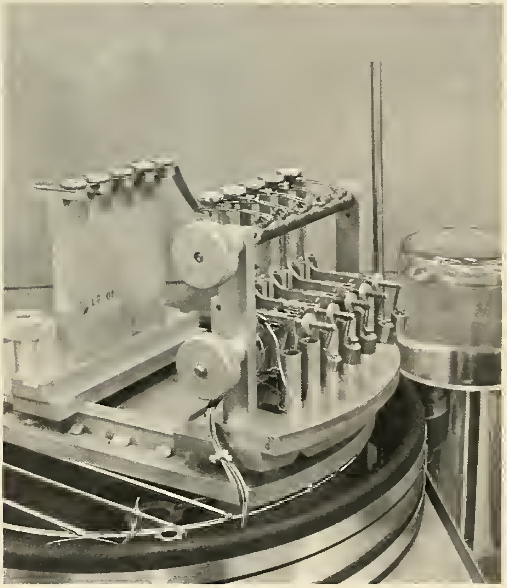
Electron-beam welding techniques are constantly being updated—joining thicknesses from 0.002 in. to 4 in. A host of common alloys and all refractory alloys and pure metals have been welded in varying configurations with several different types of joints.

The research efforts at Solar are often difficult to separate from production lines. The research personnel mix

RIGHT: Liquid hydrogen vacuum-jacketed duct simulator in use at Solar to investigate feasibility of using a cryopumped vacuum jacket insulation in conjunction with liquid hydrogen transfer lines. If this approach proves out, it will be possible to seal the vacuum space during manufacture at atmospheric pressures. BELOW: Solar is building the Apollo Command Module antenna shown here, as well as the antenna for the LEM. Both are fashioned using lightweight design concepts while meeting the system's environmental demands. The antenna illustrates Solar ability in foil fabrication. LOWER RIGHT: Static fatigue tester, shown here in the fiber mounting position, is used to develop stress corrosion data on glass fiber work under varying conditions of humidity. Work is typical of the materials research pursued at Solar to acquire the understanding necessary to design with these as they become standard engineering items with the customer.







rather freely with pilot and main production lines and the result is quick, effective solutions to production problems. The reverse is true also. Research personnel acquire a familiarity with the production area.

The increasing interest in composite materials throughout the missile/space industry is reflected in Solar research. The firm has a single-bushing glass furnace and a plastics research department.

Fiber work at Solar is similar to the metallurgical work—the effort is more toward understanding those characteristics of the fibers that have direct bearing on fabrications and final structural integrity.

In addition, researchers have developed test techniques to characterize flaws in glass fibers and to understand stress corrosion. The plastics research at Solar has resulted in significant improvements in the polyimide area as well as in metal bonding and honeycomb fabrication.

Coatings—Coatings represent another long-term technology area in Solar. O. V. Long, Solar's research director, says high-temperature coatings goals are becoming more realistic. As with many other areas of materials technology, compromises must necessarily be made.

Long says the intelligent approach to high-temperature service problems lies in improving the base materials instead of hoping a coating breakthrough will solve the problem. Long-term coatings themselves are more likely to evolve from forcing materials to create their own—thus achieving a fail-safe condition. ■

Grumman's capabilities in space projects
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Russians Release New Biology Reports

Heather M. David

WASHINGTON—Space scientists in the Soviet Union have developed equipment to automatically bring animals into a hibernation-like hypothermic state.

Experiments with the device are described in a newly translated collection of Soviet research papers published by the USSR Academy of Sciences under the title "Problems of Space Biology." Editor of the collection was N. M. Sisakyan, Academician and leading space medicine specialist who died recently.

Russian scientist G. N. Il'yutkin, describing hypothermia as a possible method of "increasing the stability of the organism against unfavorable effects produced on the organism of a cosmonaut during interplanetary flight" reports that a cybernetic apparatus has been built to produce reversible and controlled hypothermia.

Forty-six experiments were carried out with dogs, Il'yutkin says, 31 of them with manual control of the apparatus and 15 with automatic control.

He says the dogs were observed for one year, during which some of them were exposed to hypothermia several times, and it was found that there was no pronounced variation in their state, and no persistent pathological variations.

Prototype spaceflight equipment apparently has been constructed, it is indicated in another paper written by Il'yutkin with a group of other scientists.

The test procedure with the dogs began with a morphine injection, after which the animals were fitted with masks through which a nitrous oxide anesthetic was applied.

The automatic cooling device then began lowering the dogs' body temperatures at an average rate of 4°C per hour. Respiration rate decreased, along with pulse and pulmonary ventilation. The hypothermic state was reached at from 22 to 25°C. Animals were kept in this state up to 18 hours.

The device automatically fed oxygen if an animal's frequency and depth of respiration changed.

After a preassigned time, the timing system turned off the cooling system and the animal was heated at a rate from 2°C per hour until 25°C, then more rapidly at 4°C until it reached 30°C.

Details of the cooling and control system were contained in the papers. The Soviet researchers said solid-state components were used, making it possible to produce equipment sufficiently portable for use aboard a spacecraft.

Radiation—Quite a large percentage of the new flood of space biology papers deals with various aspects of the problems of radiation, in which the Soviets have shown perhaps an even deeper interest than have their U.S. counterparts.

A group of scientists led by M. A. Arsen'yeva reports that further studies indicate that various combinations of vibration or acceleration with irradiation produce physiological changes which may bring about a series of aberrations in cell division. These, in turn, may give rise to a peculiar "protective" effect against radiation.

In all cases, the Soviet scientists say, the reduction in radiation effect is caused by a reduction of true chromosome-rearrangement frequency. This may vary with time of exposure to acceleration or vibration as well as intensities, and with the amount of radiation applied.

However, the researchers indicated that after accelerations of 8 g for 15 minutes and irradiations of 100 rad at either one hour or four hours following, there were notable differences in nuclear damage compared with that of the non-accelerated controls.

With even more powerful radiation —350 r administered either 24 hours after or before vibration of one hour at 700 cps or acceleration of 10 g for 30 minutes—longer-lasting results were noted.

It was found that centrifugation or vibration before the nuclear exposure produced better results, and tangible reductions were observed on the seventh day.

Drug protection—According to S. P. Yarmonenko and A. G. Konoplyannikov, the most effective protectors against the three kinds of ionizing radiation studied are derivatives of the aminothiol and indolyl alkylamine groups.

This is generally borne out by V. S. Shashkov and V. S. Morozov, who report that in experiments with white mice irradiated with 660-MeV protons the most effective prophylactic agents, as with gamma radiation, were AET and 5-methoxytryptamine.

Protective effects of systamine and serotonin also were analogous in their use with proton exposure and gamma radiation. Effectiveness of the same drugs was found to be retained for 120-MeV proton experiments as well in doses of 1,200 rad.

However, Yarmonenko notes cautiously that the indolyl alkylamines may be somewhat less effective against proton and gamma irradiation, possibly because they are less effective against the radiation lesions of the intestines which occur quite often in these cases.

This group also reports progress in the protection of yeast cells under the influence of anoxia, glycerin and sulfur-containing compounds, both for proton and gamma irradiation.

Shielding, especially of the abdominal region, is greatly beneficial in radiation protection, including 120-MeV protons in the 800 to 1,050-rad dose area, another group led by B. L. Razgorov reports. While a shield 4 cm wide reduces the absorbed dose only by 25% for a gamma irradiation of rats in a 1,400-rad dose—still a lethal dose for unshielded animals—almost all the animals survived.

This graphically illustrates, the scientists say, that shielding is effective not so much in the reduction in the absorbed dose as in preservation of sectors of uninjured tissues located behind the shield.

Some of the chemical preparations known to be effective in protection against radiation are equally effective against genetic damage, suggests another group, led by N. N. Zhukov-Verezhnikov.

Orbital spaceflights, the Soviets relate, have yielded data that there is a small but statistically reliable increase in the level of induced phage formation in such specimens as *E. coli* bacteria.

Contact between a culture of *E. coli* and almost all preparations in the aminothiol group reduced the level of induced phage production during X-irradiation, they said, except for AET, whose values were so low as to be unreliable.

This circumstance, the Soviets said, is especially interesting because it opens new perspectives in comparative investigation of the connection between the chemical structure of preparations and their capacity to guard the organs against severe radiation injury on one hand and genetic sequelae on the other.

Vestibular tests—Soviet scientists O. G. Gazenko and B. B. Yegorov and others are apparently working toward developing a simple model of the inner ear to clarify certain properties of this organ in various gravitational fields.

In experiments which sound somewhat similar to work going on at Ames Research Center, the Soviets said they recorded the action potentials on the receptors and on the neurons of animal vestibular apparatus during mechanical accelerations. These included measurement of action potentials of individual efferent fibers in the macula utriculi, the report indicates.

Future work, the group said, will make it possible to construct an electric model for extensive investigations of the functions performed by the vestibular apparatus.

Other vestibular work in the Soviet Union, Ye. M. Yuganov reports, has dealt with testing in aircraft flying in Keplerian trajectory. During the weightless parabola the subjects also were rotated by devices in the plane.

In 33 subjects, Yuganov reports, rotation was subjectively easier to undergo than on the ground, and in a number of instances there was no illusion of counterrotation.

In the great majority of cases in which the illusion was experienced, said Yuganov, it was noticeably shorter in duration than when the same experiment was performed with the same subject on the ground.

Postrotational nystagmus—rolling of the eyes which indicates disorientation—during weightlessness decreased in all the subjects, he said. Range in time for the weightlessness experiments was from 6 to 17 seconds, compared with ground experience of from 19 to 30 seconds.

Coriolis acceleration effect on the vestibular system during weightlessness also was studied. The latent period of the "rocking" illusion was found to last longer than in similar studies on the ground.

In summary, Yuganov reports that in practically all the experiments and for all subjects, the latent period for the onset of reactions increased, but the intensity of the reactions decreased.

Overall, he said, the data indicated a lowered excitation for the semicircular part of the vestibular apparatus. In addition, Yuganov said, further tests indicated that weightlessness does not produce a functional disconnection of the otolith apparatus, but acts rather as an unusual minus-stimulus responsible for the onset of specific vestibular reaction.

Closed systems—Some interesting advanced concepts of closed ecological life-support systems are contained in the volume.

Several investigators led by I. A. Abakumova conclude that chickens and ducks are the most suitable for spaceflight use, since fowl produce highly nutritious and tasty meat and eggs, show a high weight increase per unit of feed, and grow rapidly.

Chickens and ducks can be fed unicellular algae, man's food wastes and wastes from slaughtered fowl, the authors say, and offspring can be produced by incubating the eggs. Ducklings of the Peking breed are suggested.

Political overtones are apparent as another group led by I. V. Tsvetkova has studied Chinese cabbage which might be raised in air. According to the authors, a nutrient solution was periodically and automatically sprayed near the plant's roots every 20 minutes.

However, it was found that mineralized human metabolites would not suffice for plant food, although only the addition of mineral salts was necessary. The Soviets termed "promising" this research for space application.

Personal hygiene—Changes have recorded in the physiological, chemical and bacteriological indices of the skin of human beings confined to a small space for a long period of time, V. F. Talapin reports.

According to Talapin, the elasticity of some portions of human skin is altered greatly—by about twice the original value. This could restrict movement as well as have psychological effects, V. V. Levashov says. He calls for further study of personal hygiene methods.

However, another group of scientists led by I. G. Popov report that tests with spacesuit-type garments indicate that such clothing can be worn on the skin for 30 days without any hygienic treatment, and without appreciably affecting the skin.

Popov reported on the selection of a sports-type of outer clothing made of a knitted fabric for the cosmonauts, along with slippers made of chamois.

Atmospheres—The argument over the relative merits of helium and nitrogen for two-gas spacecraft atmospheric systems has strong proponents on either side in the Soviet Union, just as it has in the United States.

B. M. Savin writes flatly that "atmospheric nitrogen is . . . hardly desirable as a component for the microatmosphere of a spacecraft cabin because of its specific gravity, solubility in biological substrates, capacity for forming toxic compounds and for other reasons."

Experiments on chick embryos, frog-egg cells and mice proved that the lack of nitrogen has no effect on developing organisms, nor was there any specific effect from helium, Savin reported.

Experiments with dogs, Savin added, indicated that the temperature comfort zone with helium is about 3-3.5° higher than that of ordinary air. ■

Apollo, MOL Simulator Testing Pressed

Four airmen at the Air Force School of Aerospace Medicine emerged last week from the space cabin simulator after a 30-day test during which two of them lived in a research chamber breathing a 70% oxygen, 30% helium atmosphere at 5 psi.

While the atmosphere test presumably is an effort by the Air Force to get further data with which to make the *Manned Orbiting Laboratory* atmosphere decision, the announced purpose of the test was to evaluate freeze dehydrated and bite-size foods—the *Apollo* diet—for NASA.

The other two subjects lived in a chamber at normal atmospheric pressure and nitrogren/oxygen gaseous composition. A SAM official said the study was made to determine the differences in nutritional and fluid requirements posed by environmental conditions peculiar to space missions.

At North American Aviation, a three-man industry crew embarked upon a test of indefinite length of the *Apollo* Command Module environmental control system. Garrett's AiResearch Manufacturing Division is subcontractor for the ECS equipment.

Earlier this month, further tests of the helium/oxygen environment were carried out at Douglas Aircraft Co.'s Missile and Space Systems Division. In addition to the test of the 5-psi gaseous mixture, the crew members decompressed to 3.5 psi spacesuit atmospheric conditions in which 100% oxygen was breathed.

A number of life-support subsystems which could be used for 30 days in space without resupply were tested. Among them were the two-gas atmospheric supply and control unit, regenerative carbon-dioxide removal equipment, systems for temperature, odor and humidity control, and waste management and personal hygiene equipment.

Phase Two Poseidon Contracts Let

Charles D. LaFond

WASHINGTON—New contracts expected to approach $115 million for up to a five-year-long Phase 2 development of *Poseidon* fleet ballistic missile (FBM) guidance, fire-control and support systems, and launcher tubes, were announced last week by the Navy's Special Projects Office, weapon-system manager, to Massachusetts Institute of Technology, General Electric Co., Raytheon Co., and Westinghouse Electric Corp.

The inertial guidance subsystem, expected to be some 15% larger but physically similar in design to the *Polaris A-3* inertial measurement unit, is being developed by the General Electric Co. and Raytheon Co. under the direction of MIT's Instrumentation Laboratory, system designer. MIT's contract is believed to exceed $22 million.

Raytheon Co. will build the associated MIT-designed digital guidance-computer subsystem under a separate contract, the Navy said. Raytheon's contract is believed to exceed $10 million.

GE's contract, valued at more than $80 million, calls for development of a third-generation fire-control system which will evolve from the present Mark 84 system used with *Polaris A-3* FBM's. GE also will provide development support to MIT for the guidance-system inertial measurement unit and will integrate guidance subsystems—platform, computer, and associated electronics.

Both the guidance system and fire-control system contracts include development of all the support equipment necessary for test, simulation, and checkout and for handling and transport.

Initial contracting—Phase 1 study contracts, now completed, were awarded for guidance to the industry-university team and to GE alone for fire-control last year after President Johnson's Jan. 18, 1965, announcement revealing initiation of the *Poseidon* program. The five-year design and development stretchout reflects present DOD-imposed funding limitations.

Westinghouse, previous prime contractor for *Polaris*-submarine missile launching and handling equipment, was selected last year to perform a program-definition-phase study for similar hardware and submarine modification needs for *Poseidon*. Its new contract, totaling $1 million through July 1 of this year, calls for start of design and development for the manufacturing of *Poseidon* launchers on a pilot-line production basis.

Submarine modifications, said Westinghouse, are expected to be relatively minor and inexpensive. Only the inner launch tube of the existing *Polaris* launchers need be replaced. This, the firm disclosed, is because of the shock-foam-support concept employed in present launchers, which not only provides a better launch facility than that used earlier but also provides for a future space and weight capability growth. Also, the new steam-eject system that is now operational has a capability to handle the larger *Poseidon*—expected to have twice the weight of a *Polaris A-3*.

Poseidon will go aboard fleet ballistic missile submarines such as this one, which carries the smaller Polaris A-3.

More effective FBM—A direct outgrowth of the highly successful *Polaris* program, the *Poseidon* is expected to be capable of providing up to a 100% increase in payload with a range equal to the 2,500-mile *A-3 missile.* (President Johnson stated in January, 1965, that the system will double the payload and the accuracy of the *A-3* and provide a factor-of-eight improvement in effectiveness as a nuclear deterrent.)

The new FBM will measure approximately 6 ft. in dia. and be 34 ft. long (*A-3* measures 4.5 ft. dia. x 31 ft.) and thus will require the modification of firing tubes on those FBM submarines designated to carry *Poseidon.*

Twenty-nine nuclear *Polaris* subs are now operational, armed with *A-2* (1,500-mile range) and *A-3* missiles. By 1968, the programmed fleet of 41 undersea craft should be operational, with 13 slated for *A-2's* and 29 equipped with *A-3's*.

Defense Secretary Robert S. McNamara has indicated previously (M/R, Oct. 25, p. 16) that the total *Poseidon* development effort will approach $900 million. The number of submarines to carry *Poseidon* missiles apparently has not yet been fixed but McNamara has stated that an additional $1.1 billion would be required to retrofit 19 boats to accommodate the weapon.

Lockheed Missiles & Space Co., developer and producer of the *Polaris* series, was selected as *Poseidon* prime contractor last October. Total development funding for Lockheed is expected to exceed $90 million over a 4-5 year period.

A Hercules Powder Co./Thiokol Chemical Corp. team will develop the missile's first stage and Hercules will develop the second stage.

Guidance and fire control—The *Poseidon* inertial platform employs three spherical gimbals for the yaw, pitch, and roll axes. Principal inertial reference sensors used are integrating gyros plus accelerometers to sense motion change in each axis.

Accelerations from ship motions are obtained from the launch submarine's SINS (Ships Inertial Navigation System) and computed by the fire-control system as one set of many launch parameters to be fed into the *Poseidon* guidance computer.

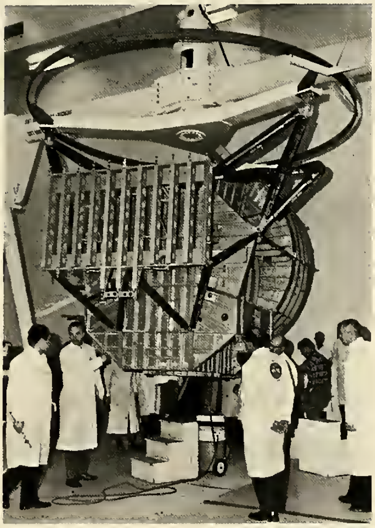
Both the supporting electronics package and the on-board digital computer for the new guidance system will make extensive use of integrated circuits, according to GE and Raytheon.

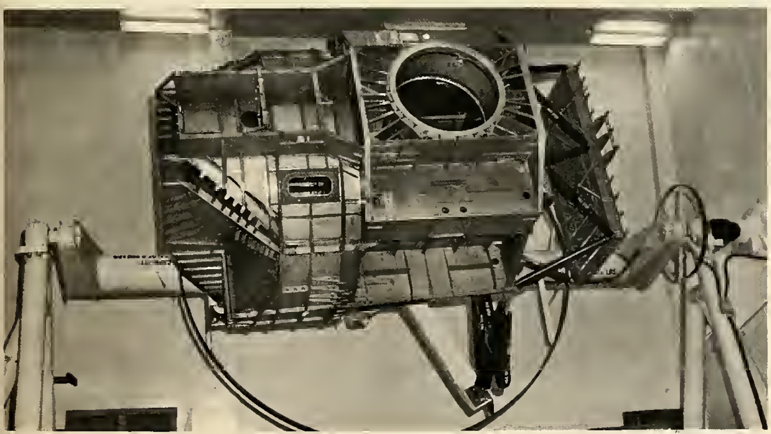
The fire-control system, GE says, will be based on "built-in follow-on capabilities of the *Polaris* Mk 84 system." The firm indicated, however, that factory modification of the Mk 84 will require "significant advances for system components and a more complex circuitry." It is believed the fire-control system and the missile itself will require a greatly beefed-up high-speed, digital computer to satisfy the *Poseidon* needs for more sophisticated penetration capability. The latter will be a general-purpose digital computer providing considerably more operational flexibility.

Ultimate changeover to accommodate *Poseidon* missile-support systems will be made on selected submarines during regular overhaul, GE says. Considerable change is expected because the fire-control system includes static and dynamic missile alignment equipment, checkout, a display console, operating controls, temperature controls, and power subsystems. ■

Grumman-Built Fixture Assists in LEM Cleaning

Engineers at Grumman Aircraft Engineering Corp. worked almost a full year to develop this cleaning positioner for the Lunar Excursion Module built by Grumman. The fixture is a large, electric motor-driven device that tumbles one of the LEM's two sections at nearly any angle to dislodge debris such as metal chips and dirt that collect during fabrication. The debris must be removed during the LEM's final buildup phase. The fixture can be stopped at various positions, so that normally inaccessible debris is shaken loose, and can be easily vacuumed out by workmen. Grumman builds the LEM for NASA. The unit will transport two astronauts to the lunar surface in the landing phase of Project Apollo.





OPERATIONS ANALYSTS

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Deep-Sea Effort Rivals Space Program

Willard E. Wilks

Los Angeles—Military and industrial experts associated with the Navy's Deep Submergence Systems Project (DSSP) foresee it leading to more practical military and civilian "fallout" than the space program can produce in the immediate future.

These officials believe the broad-ranging DSSP effort already is a turning point providing the biggest boost yet to applied research and engineering in the oceans.

Oceanographers believe DSSP is the ocean equivalent of the manned space program and more, encompassing all the basic elements of the latter—including international political problems—as well as being aimed at more immediate operational applications.

Further, it contains elements with inherent direct transferability, with little or no development or modification necessary, to a significant range of existing effort and industry, including offshore oil drilling, commercial diving, commercial fishing and fisheries research, recovery and salvage of small and large objects, and anti-submarine warfare.

As one spokesman observed, "There may be food and minerals on other planets, but the ocean is a lot closer."

Although the announced primary urgency of DSSP is development of a deep-submergence rescue vehicle (DSRV) enabling rescue of personnel near present submarine collapse depths, Navy spokesmen regard that as only one of numerous goals. The program is far broader, much of the activity being hidden by security and by association with a welter of other Navy efforts. It encompasses objectives that are of greater urgency than DSRV development as far as national security is concerned, and its potential military value is incalculable—as is its likely impact on ocean research.

Strategic potential—"The deep ocean and developmental activity in it holds the potential for changing the nature of our strategic posture," one source told Missiles and Rockets, "either by giving us a breakthrough or enabling one for someone else. In one sense, the deep-ocean program is like the space program, in that we can't permit an enemy to get an edge on us by not investigating the greater depths ourselves—at least we must have the capability of denying or monitoring their use."

Considerations have included whether it would be possible to hide strategic emplacements on the ocean floor, and the need for the capability to search them out.

A more immediate achievement will be a breakthrough in combatant submarine collapse depths if pressure hull materials now in development become available. Merely charting the deep ocean topography to eliminate interference by undersea mountains with long-range acoustic propagation would greatly aid the combatant force.

Achievement of greater depth capability alone will enable submarines to better evade enemy vehicles and weapons, and fuller knowledge of thermal and marine life interference with sound propagation will accomplish the same thing.

The Navy would like a greater range of operating depths to be able to select those best suited, for acoustic purposes, for attack or evasion. A most important question is whether the nuclear submarine can be nullified.

Military salvage—One military objective not openly discussed but rated by some spokesmen as important as rescue because of its relation to U.S. security will be met by the DSRV project and other elements of the DSSP. This is the location, inspection and recovery of U.S. submarines that may disappear in the future. It would be important to determine whether an unfriendly submarine was responsible for the disappearance, possibly tipping off an enemy breakthrough. In any event, the U.S. would not want an intact submarine being salvaged by anyone else.

The salvage requirement calls for, among other things, development of a 20,000-ft.-capability search vehicle in addition to the DSRV.

DSSP creates a need for advanced technology application over a broad spectrum. It covers, in addition to DSRV, efforts to develop manned installations on the continental shelf for salvage and exploratory and research purposes, improve existing escape systems, and to bring up objects ranging from missile components to sunken ships weighing up to 1,000 tons from depths never before attempted.

Needs include new sensors, hull materials, new structures and undersea construction techniques, swimmer propulsion units, salvage huts, improved rubber suits, improved deep-sea cutting and welding techniques, new tools, improved navigation and control systems, new lightweight nuclear and fuel-cell power plants, life-support systems, and improved manipulators.

The effect on oceanographic research will be two-fold: Not only will the DSSP spur research to solve pressing problems, it will also produce new tools and vehicles, both submersible and surface, enabling expansion of world-wide U.S. oceanographic activity.

The scope—The DSSP is aimed at achievement of at least seven distinct missions. First objective is procurement of at least five operational DSRV's in six years. These will be strategically located around the globe for quick rescue capability. This project alone includes:

—Modification of 50 nuclear submarines—the entire force—to mate with, transport and support the DSRVs. Some *Polaris* subs also may be modified for this task. Any one of the fleet of modified submarines will be able to take on an immediate DSRV assignment.

—A world-wide network of ports properly equipped with pier space, airstrip, roads, deep water, a crane and other equipment to handle the DSRVs and their mother submarines. First stage of this involves study of likely ports.

—Development of large catamarans designed as auxiliary submarine rescue (ASR) ships. This is in the design stage at the Bureau of Ships.

—C-131-size aircraft available to fly the DSRVs and checkout equipment to any of the ports.

Navy "comeback"—Those associated with ocean science and engineering in the military and industry see development of undersea capability eventually playing as important a role in the military, political and economic strength of a nation as did building of surface sea power in an earlier age.

These spokesmen think DSSP provides the springboard for such a new era of development. They also see the DSSP as the Navy's answer to the Air Force and NASA having acquired the major roles in space—a way for the

PERRY CUBMARINE

Navy's DSSP could lead to development of deep-diving submersibles such as the Perry Cubmarine, being used in attempt to retrieve H-bomb lost off the coast of Spain after aircraft collision. Vessel was made by Perry Submarine Builders, Inc.

Navy to "come back into its own."

But whatever the "blue sky" aspects of current discussions and speculations about hydrospace, the DSSP is capturing the imagination and drawing together scattered elements which, integrated with the systems approach into a single program, present a powerful potential.

With the DSRV and the deep search vehicle (DSV), 98% of the ocean floor can be covered. The idea of the DSRV project "is to have enough of them located throughout the world for an overall rescue mission capability of 36 hours—elapsed time until the last man is rescued," spokesmen say.

Plans call for five operational DSRVs following development of one prototype. These, with an operating depth of 6,000 ft., can be used for deep research at their various locations when not otherwise engaged. The DSV program calls for one prototype submarine with a 6,000-ft. operating depth, and four operational vehicles with 20,000-ft. capability. These also will be used for research and exploration.

Importantly, both these projects can put man on the scene. The entire DSSP, in fact, emphasizes the role man will play in the system.

As a result of the Thresher disaster three years ago—the main spur to creation of the DSSP—the Navy found a single military objective that could justify a program—unlike the Air Force, which had to shelve some detailed and ambitious plans for Moon exploration because it lacked a clear-cut military reason, among other things.

Intermediate goals—The nature of this objective is such that it must attain other important goals in order to achieve the original, thereby providing many other benefits en route. This can be seen in the bare outline of the program schedule for the DSSP, which lumps objectives into four main groups. These, with current milestone dates, include:

Man-in-the-sea—Modification of an existing ship to support the project to be completed in November, 1966; Sealab III bardware on the bottom, January, 1967; begin technical and operational evaluation of Seahab (Sealab III follow-on), February, 1968; Seahab operational January, 1969. (Seahab's operational depth on the continental shelf remains to be determined in the Sealab III experiment.)

Submarine location, escape and rescue system—This covers both the DSRV for deep rescue and a project to improve and extend two current methods of submarine personnel escape, one permitting escape without outside assistance from depths down to 800 ft., the other extending rescue capability with the McCann chamber.

Extension of the free-escape system reportedly will require development of new suits and associated equipment. Schedule currently calls for completion of installation of suits and life rafts in submarines Jan. 15, 1968. Other current target dates: begin evaluation of the DSRV prototype vehicle July 15, 1968; begin an experimental 600-800 ft. open-sea free escape Aug. 1, 1968; complete modifications to an existing ship for use as an auxiliary submarine rescue (ASR) vessel Nov. 1, 1968; begin evaluation of first five operational DSRVs June 15, 1970; systems become operational April 1, 1972.

Object location and small object recovery system—Complete alerting and marking aids to be carried by both submarine rescue and search vessels, April, 1967; complete world-wide oceanographic data collection project, July, 1968, so that data on ocean conditions, including bottom topography, would be immediately available for rescue or salvage forces wherever disaster may occur; test search vehicle, modified floating dock support ship, and towed instrument platform operational, July, 1970.

Large object salvage system (LOSS)—Start system studies, April, 1966; complete modifications to auxiliary salvage ship 2 and auxiliary submarine rescue ship (surface support vessels), May, 1968; complete system evaluation, July, 1969; complete evaluation of auxiliary salvage ship 4 and auxiliary submarine rescue ship 2, July 1971; LOSS operation, November, 1971.

Come the catamarans—At some future date beyond those currently in the schedule, specially developed catamarans would replace both the salvage and submarine rescue support ships. Stability is the main factor considered in using the catamaran configuration, as well as the fact that the twin hulls would permit both the DSRV and search submarines to surface between the hulls to be taken aboard.

The man-in-the-sea project is tied closely to the salvage project, with undersea salvage huts and associated environmental and other support equipment required. Among the many new items needed here are power units that can operate in the high-pressure atmospheres required in undersea habitats.

Capacity of the DSRVs will be 12 to 14, with two operators and one crew-

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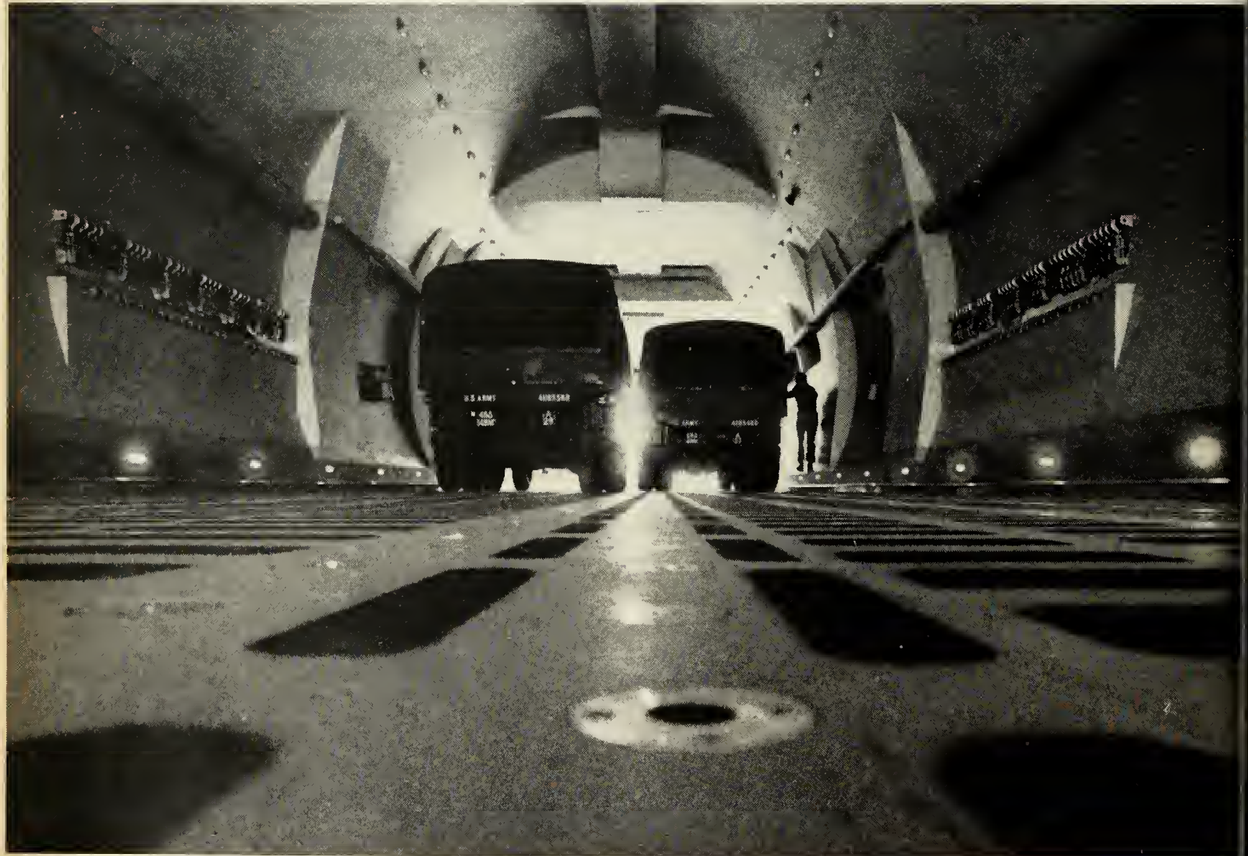

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man, according to present planning.

Configuration will be three pressure spheres contained within an outer hull. The forward sphere will house the two operators, the central compartment will be for entry, and the aft sphere will carry survivors.

Existing sub use—Modifications to the submarine force to accommodate the DSRV will be as minimal as possible. These will include automatically released buoys in event a disabled sub is below tethered depth, acoustic pingers, explosive charges located on the hull, and internal arrangements such as cabling to forward and aft hatches to attach to the mated DSRV. A cradle to hold the DSRV during air, surface and submarine transportation, and to aid in the mating operation also is contemplated.

A checkout van will be needed, and, in addition, the program calls for a rather large amount of new equipment to be taken aboard any submarine assigned the DSRV mission. A special floating dock may be required for the mating operation. For the DSRV itself, the mating operation to the disabled submarine presents a major development problem.

The program may also include provision for a disabled submarine to relay its distress message via a communications satellite through the buoy it releases.

As envisioned now, the deep search vehicle will be about the same size as the DSRV, though a different configuration will be required. Thought is being given to using the aft sphere for additional equipment for search.

Peripheral efforts—There are a number of Navy efforts under way that tie into the DSSP although they are not contracted through this program. This includes sensor work. Industry is investigating application of filament winding to an escape capsule. Work on a deck decompression chamber and a personnel transfer capsule also is under way at Electric Boat Div. of General Dynamics.

The very deep portion of the salvage project—at greater than continental shelf depths—will require development of new equipment and systems for use at depths where man cannot go, although the manipulator-equipped deep submersibles can aid in this. This implies new techniques required at the surface end of deep salvage operations. New tools such as collapsible pontoons, lights and cutting and welding equipment are needed for salvage at any depth.

A significant point to the industry is that an aerospace company, Northrop Corp., has the contract to assist the Navy in management and systems integration. Although an aerospace firm had a major role in the *Polaris* system, DSSP spokesmen regard the Northrop role as broader. In comparing the DSSP to the *Polaris* project, they add that complexity of certain subsystems may exceed that of the weapon system.

Northrop responsibilities—The Northrop role in the program is split into numerous tasks:

Task 1A—In accordance with the DSSP coordination drawing instruction, the company will instruct DSSP contractors in the content of DSSP instruction, examine all coordination drawings and changes thereto, maintain a file of DSSP coordination drawings, process coordination drawings through proper authentication channels.

Task 1B—Establish coordination drawings for all DSSP salvage systems components such as undersea huts, pontoons, underwater decompression chambers, and their interfaces with salvage ships, diver support ships, transportation equipment and storage equipment; all DSSP man-in-the-sea system components such as undersea habitats, decompression chambers, personnel transfer chambers, and their interfaces with diver support ships, support barges and land stations; all DSSP vehicle interfaces with support ships, submarines, storage and handling cradles, land transport vehicles, aircraft, vehicle support vans and other vehicle interfaces with items external to the vehicle.

Task 2—Assist in establishing and maintaining DSSP system specifications, reliability requirements, program schedules, cost-effectiveness studies, maintenance philosophy and inspection and quality assurance requirements.

Eleven other tasks are: assist in establishing DSSP systems documentation requirements, including requirements for maintenance, test and operating manuals; assist in manual review; assist in analyzing DSSP performance data and make recommendations for improvement; assist in evaluating proposed system and subsystem modifications as to their need, adequacy and cost; assist in evaluating DSSP spare parts requirements.

Also, assist in writing and evaluating DSSP change proposals, technical development plans, or other similar documents required to support any deep-submergence system; assist in preparing DSSP documents such as instructions and notices; assist in preparing and analyzing PERT programs for DSSP; assist DSSP in training program requirements such as type of training, curricula and sites for training; assist DSSP system managers in examining human engineering requirements of the DSSP systems; assist in preparing mission analyses and operational sequences; assist in establishing and controlling DSSP drawing requirements. ■

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The Industry Week

Mergers and Acquisitions

Controls Co. of America, Melrose Park, Ill., has purchased the product lines and certain assets of Deutsch Controls Corp., a subsidiary of Deutsch Co., Los Angeles. . . . *Northern Scientific, Inc., Madison, Wis., will merge into TRACOR, Inc., Austin, Tex. Northern Scientific manufactures digital memory oscilloscopes and pulse height analyzers. TRACOR does research, development and manufacturing in the electronic instrument field.* . . . HITCO., Gardena, Calif., will acquire the N. R. Buck Co., Lakeville, Minn., for an undisclosed amount of HITCO stock. Buck produces copper-plastic film laminates and printed circuits. . . . *Norton Co., Worcester, Mass., will acquire all the stock of Chamberlain Engineering Corp. and the principal assets of the U.S. Stoneware Co., both of Akron, Ohio. U.S. Stoneware produces ceramic, metal and plastic supplies for the chemical process industry. Chamberlain products include reinforced plastics, radomes and molded rubber parts.* . . . Brooks Instrument Div. of Emerson Electric Co., Hatfield, Pa., has purchased manufacturing and marketing rights to a line of magnetic flowmeters previously developed and produced by Hays Corp., Michigan City, Ind. . . . *Hoffman Electronics Corp., El Monte, Calif., has acquired all assets of AVAK Corp., an audio-visual equipment and training firm. AVAK will become part of a new subsidiary, Hoffman Information Systems, Inc.* . . . Allied Research Associates, Inc., Concord, Mass., has purchased the assets of the Aerospace Div. of Aeronca Manufacturing Corp. The division, located at Friendship International Airport, Baltimore, Md., manufactures mechanical and electronic equipment and assemblies.

International

Sperry Rand Canada, Ltd., has been formed in Toronto, Ontario, by the consolidation of six former Canadian subsidiaries of Sperry Rand Corp. B. Wensley King will head the new subsidiary, which operates four manufacturing plants in Canada. . . . *Ryan Aeronautical Co., San Diego, Calif., has selected Manufacture Belge de Lampes et de Material Electronique, Brussels, Belgium, to manufacture and sell the firm's Firefish target system.* . . . ITT Industries of Canada, Ltd., has been formed in Guelph, Ontario, by International Telephone and Telegraph Corp. The new firm will develop, manufacture and service equipment for the ITT Fluid Handling Div., Morton Grove, Ill. . . . *Six European countries will jointly construct a $7-million observatory on a montain peak in Chile. Cooperating on the project are astronomers from Denmark, Sweden, West Germany, France, the Netherlands and Belgium.*

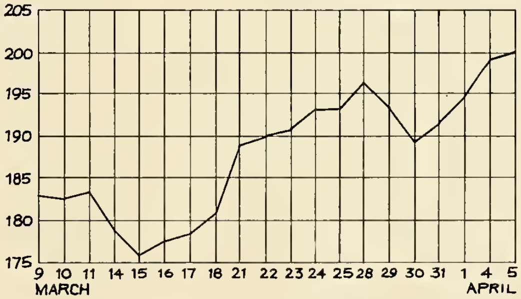
New Activities

Westinghouse Research Laboratories, Pittsburgh, has installed a new underwater research facility in the electro-acoustics department. The facility houses a 150,000-gallon water tank, 30 ft. deep and 30 ft. in diameter. Two test stations in the tank will be used to install and test underwater sound equipment. . . . *Universal Match Corp., St. Louis, Mo., is asking for stockholder approval to change the name of the firm to UMC Industries, Inc. The new name would be more indicative of the company's diverse activity, which includes production of components and systems for military and space programs.*

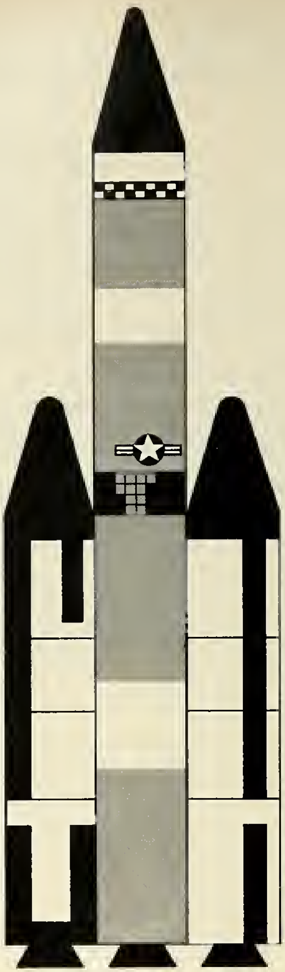
Missile/Space Stock Index

Almost 15 months to the day, the Missile/Space Weighted Stock Index passed the 200 mark, a 100% gain since the Index was first published Jan. 4, 1965. April 5 prices and percentage gains for each of the 19 stocks which make up the Index follow. These stocks were chosen to represent the industry on the basis that the companies do better than $200 million in sales each year, more than half of which is in the defense/space field, and are listed on the New York Stock Exchange.

	Close April 5	*Percentage Increase*
Avco	29¾	38.34
Bendix	81	83.06
Boeing	160	132.00
Douglas	97½	234.43
General Dynamics	61½	75.89
General Precision	60⅜	113.75
Grumman	53⅜	96.44
Lear Siegler	31	140.56
Ling-Temco-Vought	70⅜	301.87
Litton	85	127.80
Lockheed	64½	68.35
McDonnell	59	73.46
Martin	21½	19.54
North American	59¼	9.61
Northrop	27¼	30.53
Raytheon	50¼	133.66
Thiokol	20⅛	67.68
Thompson Ramo Wooldridge	46⅜	48.42
United Aircraft	90⅛	107.30
	Average Increase	100.14



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH



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Contracts

AIR FORCE

$2,200,000—**Hallicrafter Co.,** Chicago, for production of components for electronic countermeasure systems.

$1,475,000—**TRW, Inc.,** Redondo Beach, Calif., increment to an existing contract for work on a space program.

$360,800—**TRW, Inc.,** Systems Group, Redondo Beach, Calif., for investigation of radioisotope-heated propellant-reaction control systems.

$181,314—**Thiokol Chemical Corp.,** Wasatch Div., Brigham City, Utah, for development of castable cabonaceous materials for solid rocket nozzles.

$150,000—**Massachusetts Institute of Technology,** Cambridge, Mass., for study of inertial guidance testing and instrumentation methods.

$130,000—**Martin Co.,** Friendship International Airport, Md., to study the most economical ways of increasing the life-span of future spacecraft.

$65,000—**Battelle Memorial Institute,** Columbus, Ohio, for further development of the hydrostatic extrusion of fine beryllium.

$41,000—**General Dynamics Corp.,** Pomona Div., Pomona, Calif., for investigation and study for electronic countermeasure evaluator design.

ARMY

$14,467,359—**Martin Co.,** Orlando, Fla., for initial development of improved components for the *Pershing* missile system.

$5,601,785—**Philco Corp.,** Aeronutronic Div., Philadelphia, for four contracts for production support of *Shillelagh* anti-tank guided missiles.

$3,550,000—**Ling-Temco-Vought, Inc.,** Warren, Mich., for continued development of the *Lance* ballistic missile system.

$2,061,610—**Sperry Utah Co.,** Salt Lake City, Utah, to begin development of advanced ground electronic equipment for the *Sergeant* missile system.

$1,525,506—**Martin Marietta Corp.,** Orlando, Fla., fixed-price contract for supplies and services relating to test and evaluation of the *Shillelagh* anti-tank missile system.

$1,337,989—**Thurmont Construction Co.,** Thurmont, Md., fixed-price contract for construction of a guided missile maintenance shop and additions to existing structures.

$422,751—**Fairchild Camera and Instrument Corp.,** Clifton, N.J., first-year increment to a $2,212,233 three-year buy contract for electron tubes for the *Nike-Hercules* missile system.

$109,839—**Raytheon Co.,** Waltham, Mass., contract modifications for R&D of a high-power gas laser.

$98,000—**Sylvania Electric Products, Inc.,** Sylvania Electronic Systems, New York City, for investigation of vulnerability of communications satellites and associated ground equipment to electronic jamming.

$88,264—**R. Daniels, Inc.,** Daniels, Md., for radome track assembly.

$64,967—**Akwa-Downey Construction Co.,** Milwaukee, Wis., for a new telemetry tower foundation and pedestal to be built on Merritt Island for the Air Force Eastern Test Range.

NAVY

$6,711,550—**RMF, Inc.,** King of Prussia, Pa., for nozzle and fin assemblies for the 2.75-in. rocket.

$4,637,111—**Apline Geophysical Associates Inc.,** Norwood, N.J., to conduct a Marine geophysical survey program.

$2,498,000—**General Electric Co.,** Pittsfield, Mass., for design and development work on *Poseidon* missile subsystems.

$2,479,790—**Raytheon Co.,** Lexington, Mass., modification to a previously awarded contract for guidance and control groups for *Sidewinder* missiles.

$2,023,158—**Raytheon Co.,** Lexington, Mass., for engineering and design services in connection with the *Sparrow* weapon system.

$853,000—**Northrop Corp.,** Nortronics Div., Palos Verdes, Calif., for a ship's inertial navigation system (SINS) to be installed aboard the USNS Twin Falls, an Eastern Test Range missile tracking ship.

$300,000—**Whittaker Corp.,** Technical Products Div., Los Angeles, for development of an interference blinker subsystem for identification friend or foe beacon radar system, intended for use by the joint DOD AIMS program.

$183,489—**Raytheon Co.,** Missile Systems Div., Bedford, Mass., for R&D on fixed-antenna radar guidance for missile-borne applications.

$81,643—**Carborundum Co.,** Niagara Falls, N.Y., for R&D on advanced ceramic systems for rocket nozzle applications.

$46,141—**Hoffman Electronics Corp.,** Santa Barbara, Calif., for R&D program on an infrared image converter.

$25,000—**North American Aviation, Inc.,** Rocketdyne Div., McGregor, Tex., for *Sidewinder IC* rocket motor propellant improvement program.

NASA

$10,500,000—**Ling-Temco-Vought, Inc.,** Dallas, Tex., for a third-year extension of a contract for administrative services at the John F. Kennedy Space Center.

$784,000—**Electro-Mechanical Research, Inc.,** College Park, Md., from Goddard Space Flight Center for fabrication of three *Interplanetary Monitoring Platform* satellites.

$500,000—**Bendix Corp.,** Systems Div., Ann Arbor, Mich., for a study of extraterrestrial surface exploration.

$246,422—**Astrodata, Inc.,** Anaheim, Calif., from Marshall Space Flight Center for Doppler system contract.

$217,800—**International Telephone & Telegraph Corp.,** Fort Wayne, Ind., from Goddard Space Flight Center for integration support for image dissector camera subsystem.

$110,000—**Electro-Optical Systems, Inc.,** from Jet Propulsion Laboratory for design and fabrication of an 11½-ft.-dia. one-piece solar concentrator to be built from electro-formed nickel and to be used at JPL's solar test facility to evaluate capabilities of solar thermionic generators.

$96,300—**North American Aviation, Inc.,** Autonetics Div., Anaheim, Calif., from Electronics Research Center for study of spaceborne multiprocessing.

$90,000—**Wheeler Laboratories,** Great Neck, N.Y., contract modification from Electronics Research Center for continuation of analytical and experimental work on macroscopic optical waveguide and component research.

$89,500—**Northrop Corp.,** Northrop Space Labs, Huntsville, Ala., from Marshall Space Flight Center for lunar dust removal/prevention techniques for radiators on Atomic Energy Commission payloads.

$77,937—**Sylvania Electric Products, Inc.,** Sylvania Electronic Systems, Western Operations, Mountain View, Calif., from Marshall Space Flight Center to design, develop, fabricate, test and deliver a prototype high-power single-frequency-output CW laser system.

$69,800—**Battelle Memorial Institute,** Columbus, Ohio, from Electronics Research Center for high-temperature materials study.

$43,945—**Airborne Instruments Laboratory,** Deer Park, N.Y., from Electronics Research Center for continuation of development and refinement of a submillimeter power detector.

$41,793—**Allied Research Associates, Inc.,** Aracon Geophysics Div., Concord, Mass., from Goddard Space Flight Center for infrared studies of meteorological satellite data.

$39,920—**Analytical Mechanics Associates,** Westbury, N.Y., from Goddard Space Flight Center for application of nonlinear estimation theory to orbit determination.

$30,365—**Thiokol Chemical Corp.,** Elkton, Md., from Goddard Space Flight Center for 6 *Apache* rocket motors and 11 *Cajun* rocket motors.

$29,335—**Avco Corp.,** Wilmington, Mass., from Electronics Research Center for calculus of variations defined by modern functional analysis.

$19,290—**United Aircraft Corp.,** Farmington, Conn., from Electronics Research Center for celestial sensor test facility study.

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Missiles and Rockets, The Weekly of Advanced Technology, received the Jesse H. Neal Editorial Achievement Award for 1965. The award, the most cherished in business publishing, was presented to the editors of Missiles and Rockets for the best feature article or series of feature articles in all ABP member magazines with circulations of more than 40,000. Our winning entry was the September 6, 1965 "Special Report on Oceanology—exploiting and exploring the seas."

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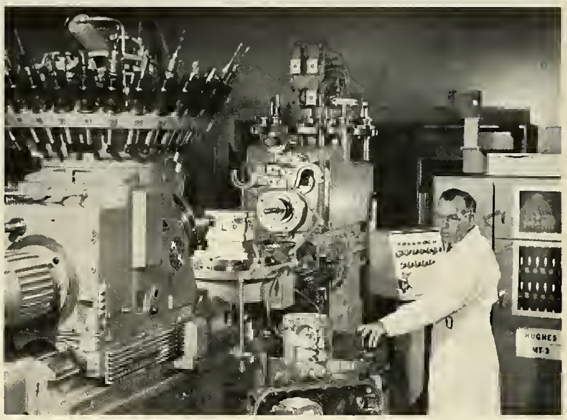
Products and Processes

New Product of the Week: Machining Center



A tape-controlled machine center that can hold 30 different tools has been developed by Hughes Industrial Systems Div.

The MT-3 machine can cut, mill, bore, drill, ream, and tap metal parts of different shapes and sizes. The universal drilling, tapping and boring head can be changed from one tool to another automatically in less than three seconds. The unit includes a face milling head and precision boring head with a 14-tool-capacity changer.

The machine is directed by an operator with an electronic numerical control system.

Circle No. 151 on Subscriber Service Card

Shaft Angle Transducer

A digital shaft angle transducer that presents a load of less than 2 gram centimeters to the sensor and eliminates the need for brush or optical-type shaft encoders has been developed by the Barton Instrument Corp.

Model X115 provides a means of obtaining accurate direct digital signals from pressure, temperature and other sensing elements employing shaft rotation output. The unit will provide a digital output, over an angular range of 180°, which has a linearity of ± 6 arc minutes and a repeatability better than ± 3 arc minutes.

Pressure units incorporating the transducer will provide differential pressure measurement with approximate linearity of ± 0.5% and repeatability of ± 0.25%. The output consists of a start pulse and a stop pulse with the timing (0 to 1 millisec.) between pulses proportional to the shaft rotation (0 to 45°).

Circle No. 152 on Subscriber Service Card

Ultrasonic Energy Source

A portable source of focused ultrasonic energy with wide industrial and scientific applications has been developed by the Powertron Div. of Giannini Controls Corp.

The device, named Sonocone, is comprised of a solid-state ultrasonic generator and a lightweight, focused probe. Its stepless power control allows an exact amount of high-intensity ultrasonic energy to be emitted into any material.

The solid-state generator provides a 125-watt average output at 20 kc. The 4.7-lb., 14½-in.-long probe focuses this ultrasound and emits it into any material being treated. The probe can be supplied with up to 10 different accessory tips for varying applications.

Tuning of the unit is by a feedback system that is self-compensating for changes in temperature and load levels. Power control is stepless, exact and repeatable. The probe may be hand held or permanently mounted.

Circle No. 153 on Subscriber Service Card

Monolithic Computer

Burroughs Corp. has announced two series of advanced electronic computer systems.

The B2500 and B3500 monolithic integrated circuit computers are designed for financial, business, governmental and scientific data processing. Memory modules and peripheral components can be added to the basic systems to enable handling of larger programs.

The B3500 can be equipped with 10,000 to 500,000 bytes of core memory with an effective cycle time of 500 μsecs per byte. The B2500 offers up to 60,000 bytes of core memory with an effective cycle time of 1 microsec. In either system core memory can be expanded on-site with plug-in core modules of 10,000 bytes or larger.

An integrated circuit address memory is used during program execution. Access time is 100 μsecs; size is variable from 24 to 120 words. The systems also feature a 100 μsec read-only memory device. Input/output channels are independent of each other. Up to 20 input/output channels are available with the B3500; six with the B2500. All channels may operate simultaneously and concurrently with computation.

Circle No. 154 on Subscriber Service Card

IC Sense Amplifiers

A family of integrated-circuit sense amplifiers for operation in industrial environments has been announced by Texas Instruments, Inc.

The SN7500 is a complete sense amplifier, including strobe gate and pulse-shaping output circuits. It detects bipolar differential input signals from a magnetic-core memory and provides the interface circuitry between memory and logic circuitry. The unit accepts low-level pulses originating in the memory, and converts them to logic levels compatible with standard integrated logic circuitry.

The amplitude-discriminating system incorporates a threshold circuit with a narrow region of uncertainty. A strobe input is provided so that threshold detector can be activated when the signal-to-noise ratio is at maximum during the system read cycle, and is inhibited during the write cycle.

Input threshold level is typically 17mv; common-mode rejection is 2v. Output pulse width is 500 μsec., and input impedance is 200 ohms. Overload recovery is less than 100 μsec. Propagation delay is 60 μsec., ON output level is less than 0.4v, and input threshold offset is 2 mv.

The unit is also available in a military version for operation in environments of —55° to 125°C.

Circle No. 155 on Subscriber Service Card

Heat Rate Sensors

A line of thin-film heat-rate sensors with a response time of less than 5 microsecs. has been developed by Astro-Space Laboratories, Inc.

The miniaturized units are mechanically protected and electrically insulated

ENGINEERS
PHYSICISTS

POLARIS SYSTEMS EVALUATION

The Applied Physics Laboratory, The Johns Hopkins University, has several immediate openings for qualified engineers and physicists to participate in pre- and post-patrol evaluation of the Polaris weapon system. Working in close association with Naval operational personnel, APL staff members develop test objectives, establish test procedures, and monitor tests at Cape Kennedy and aboard submarines. Particular emphasis is placed on the analysis of test data and the development of recommendations for improvements in system and sub-system performance. New staff members are normally assigned to a sub-system area, such as Missile, Fire Control, Navigation, or Launcher, with later opportunities for broader system assignments based on experience and knowledge. A degree in physics or electronic engineering and experience in one of the above areas are preferred.

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by a coating of vacuum-deposited silicone monoxide and are precision assembled so that the discontinuity to laminar flow on the exposed surface will always be less than 0.002 in. They are constructed to operate in evacuated environments on the order of 10^{-5} torr and temperatures up to 300°F.

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Militarized Serial Printer

Potter Instrument Co. is marketing a militarized, high-speed serial printer that provides a minimum serial print rate of 12 characters per second in a 26-column format with a 64-character complement.

Model HSP-3604 is designed for military applications in which miniaturization, reliability, and ease of maintenance are required. An odd/even drum format allows the use of double-headed hammers requiring 13 hammer modules and associated driving circuitry to provide a 26-column printout. A non-metallic flexible pivot point eliminates metal-to-metal contact.

The unit features a horizontally mounted drum containing 26 columns with 64 printable systems. The print drum contains timing marks etched on its periphery, in addition to the 64-character symbols.

Silicon semiconductors are used throughout. Temperature range is —25° to 131°F. Shock: vertical axis is 25 g's peak/40 millisecs. Vibration: 5 g's from 2 cps to 500 cps. MTBF is 2,500 hours.

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Solid-State Multimeter

A solid-state multimeter that has more than 54 ranges has been announced by Edwin Industries Corp.

Model CT471 covers dc voltage and current, ac voltage and current, and features RF to 1.5 GHz. Resistance is 2 ohms to 20 megohm center scale. Both a-c and d-c voltages have 11 ranges covering 12mv full scale to 1,200v full scale. D-C accuracy is ± 2% with 10 megohms/volt input resistance and RF accuracy of ± 0.5 db to 500 MHz

The meter withstands shock, vibration, and is waterproof The protective cover contains an assortment of test leads and probes. The NATO-approved unit is powered by three D-cell flashlight batteries

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Heating Generator

An induction heating unit consisting of a 2½-kw output generator and a temperature controller for applica-

Circuit Bonder

A circuit bonder that uses infrared detection has been announced by Texas Instruments, Inc.

Model 730 controls joint temperature to ±3% or better automatically, after simple settings are made. It is designed to bond circuit components and wiring-in assemblies to printed circuit cards, thin films, and varied assembly operations. The unit welds, brazes, hard and soft solders, and bonds, using parallel gap or opposed heads.

Temperatures from 300° to 1,400°F are accurately controlled so that operation of the cycle is automatic. Power supply has a capacity of 10,000 watt-seconds (500 amps at 2v for 10 seconds).

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tions requiring automatic temperature control has been introduced by Lepel High Frequency Laboratories, Inc.

The unit includes 15 adjustable tank taps for proper matching of any load coil and externally adjustable grid control. Silicon diode solid-state rectifiers are featured, as well as plate and grid current meters and grounded tank circuit.

SCR power control is provided for manual or automatic temperature control. Bandwidth and current limiter are adjustable, providing minimum power adjustment.

The temperature controller has a manually operated set point that may be positioned at any desired control temperature at the thermocouple. A digital set point unit or a program set point unit can be supplied.

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Temperature Cryostat

A variable temperature cryostat that provides an operating range of 4.2° to 400°K and may be operated from any cryogenic storage container has been announced by Cryonetics Corp.

The Cryojet features a high refrigeration capacity with efficient cryogen consumption, the firm says. At 20°K the unit will dissipate 3 watts with less than a one-liquid-liter-per-hour helium consumption. It also provides rapid cooldown. Temperatures of 4.2°K can be obtained from ambient in less than 10 minutes, using 0.6 liquid liters of helium.

The entire operating range can be covered with liquid nitrogen or liquid helium and the system may be vented directly to the laboratory atmosphere.

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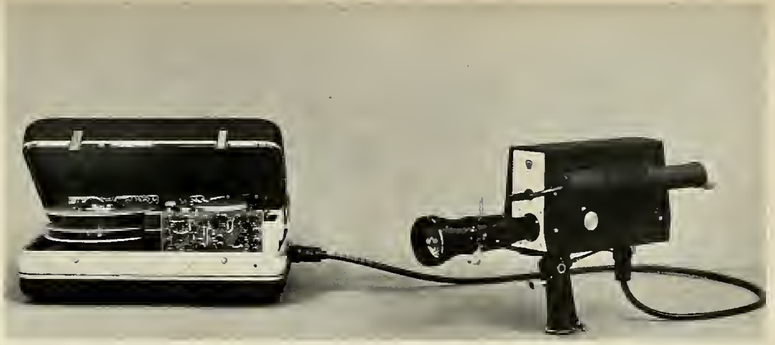

TV Recording Camera

A portable, transistorized television recording camera for aerospace and military applications, claimed to be the first of its kind, has been announced by the Westel Co.

The system consists of two lightweight units. The camera head has a "pistol grip" handle, a vidicon tube, special CRT view finder, and all focusing and video level controls. The head is connected by a cable to the recording module. Powered by rechargeable nickel-cadmium batteries, each recording unit will tape for 30 mins. on a standard 8-in. reel, with an additional 60 mins. of standby operation, and 30 mins. preview.

An electric motor with printed circuit armatures directs the 1-in.-wide magnetic tape at 10 ips around an inverted cone. The cone's mid-section, containing the single recording head, rotates within the moving "collar" of tape. A digital-computer-type servo control system checks on the head-to-tape speed relationship 15,750 times per second.

The camera permits the shooting of sound TV tapes with no external power supplies by a single person in any environment, the firm says.

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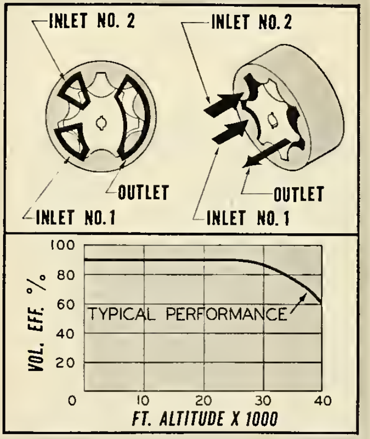

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Names in the News

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J. David Quinn: Appointed president of the Pure Carbon Co., Inc. He succeeds **M. C. Burr,** who has been named chairman of the board.

Robert Sutton Saalfield, Jr.: Named to head the new advertising sales office of American Aviation Publications, Inc., in Akron, Ohio. He was with *Newsweek* magazine for 17 years in sales and advertising management.

Brig. Gen. Harold McD. Brown: Named deputy chief for the Army's communications and electronics efforts. He has been serving as commanding general of the U.S. Army Signal Center and commandant of the U.S. Army School at Fort Monmouth, N.J.

Harvey M. Ross: Named president of OMNITEC, a new corporation established to build a line of advanced products for military and aerospace applications. He was formerly marketing director for the Western Center of Motorola's Military Electronics Div.

Dr. John L. McLucas: Elected president and chief executive officer of the MITRE Corp., effective July 1. **C. W. Halligan,** president of the company since 1958, will become chairman of the executive committee of the board of trustees.

Herbert J. Mossein: Named president of Herron Optical Co., a subsidiary of Bausch & Lomb. He will continue in his present post of vice president and marketing manager of B&L's Scientific Instrument Div.

Norman A. Evans: Elected president of Pressed Steel Tank Co. He is currently treasurer of the National Liquefied Petroleum Gas Association, and president of the Compressed Gas Association.

James R. McNitt: Elected a vice president of International Telephone and Telegraph Corp. He will continue his duties as group executive, International Communications Operations, and president of ITT World Communications, Inc.

John E. Greer: Appointed director of the Chemical Propulsion Div. of the explosives and chemical propulsion department of Hercules Powder Co.

Edward Smith: Appointed vice president of finance of Milgo Electronic Corp.

Frank Hogge: Appointed assistant to the vice president and manager of the Washington office of ARINC Research Corp. He will be responsible for supporting marketing objectives of the consulting and engineering research firm.

W. C. Bertrand: Elected to the board of directors of Information Development Co. He will assume the post of treasurer, effective Feb. 1. He was formerly assistant controller for Garrett AiResearch.

Dr. Simon Ostrach: Appointed senior engineering and research consultant for Ryan Industries, Inc. He is associated with Case Institute of Technology as professor-in-charge of fluid thermal and aerospace science.

Maj. Gen. John Martin Cone: Died March 30 of an apparent heart attack. He was commanding general of the White Sands Missile Range, N.M., for the past nine months.

W. Cameron Roberts, Jr.: Died March 25 of complications following a kidney transplant. He was co-inventor of *Arcas*—one of the world's most widely used meteorological rocket systems—and had done extensive research for the upper-air research and space programs. He had been director of the Production Div. for Atlantic Research Corp.'s propulsion and chemical systems since 1963.

Lt. Gen. Stanley R. Mickelsen: Died on March 28. He was former chief of the Army's Air Defense Command and was considered an expert on guided missiles.

J. H. Leiper: Died late last month after a sudden illness. He received the Distinguished Public Service Award from the Navy for meritorious contributions in the field of missile guidance technology. He was chiefly instrumental in the introduction of the *Sparrow III* air-to-air guided missile system into the armed forces. Leiper was a retired manager of the Raytheon Co.'s Oxnard, Calif., plant.

missiles and rockets

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When and Where

APRIL

Conference on Ground-Based Aeronomic Studies of the Lower Ionosphere, sponsored by the Air Force Cambridge Research Laboratories, Canadian Defense Research Telecommunications Establishment, Ottawa, Canada, April 11-15.

Symposium on Generalized Networks, sponsored by the Polytechnic Institute of Brooklyn, Hotel Commodore, New York City, April 12-14.

Fourth International Quantum Electronics Conference, sponsored by the American Institute of Physics, the Institute of Electrical and Electronics Engineers, Town House, Phoenix, Ariz., April 12-15.

Fourth Symposium on Remote Sensing of the Environment, sponsored by the Air Force Cambridge Research Laboratories, Office of Naval Research, University of Michigan, Ann Arbor, Mich., April 12-14.

Annual Technical Meeting and Equipment Exposition, sponsored by the Institute of Environmental Sciences, El Cortez Hotel, San Diego, Calif., April 13-15.

Second International Conference on Electron and Ion Beam Science and Technology, sponsored by the Electrochemical Society and the Institute of Metals Div., Park-Sheraton Hotel, New York City, April 17-20.

Annual Engineering Conference and Tool Exposition, sponsored by the American Society of Tool & Manufacturing Engineers, Statler and Sheraton-Cadillac Hotels, Detroit, April 18-22.

National Association of Corrosion Engineers 22nd Annual Conference and Corrosion Show, Fountainebleau, Miami Beach, Fla., April 18-22.

Metals Engineering Conference, sponsored by the American Society of Mechanical Engineers, Sheraton-Cleveland, Cleveland, April 18-22.

37th Annual Scientific Meeting of the Aerospace Medical Association, Dunes Hotel, Las Vegas, April 18-21.

Seventh Structures and Materials Conference, sponsored by the American Institute of Aeronautics and Astronautics, American Society of Mechanical Engineers, Cocoa Beach, Fla., April 18-20.

Annual Frequency Control Symposium, sponsored by the U.S. Army Electronics Command, Shelburne Hotel, Atlantic City, N.J., April 18-20.

Spring Meeting of the International Scientific Radio Union and the Institute of Electrical and Electronics Engineers, National Academy of Sciences, Washington, D.C., April 18-21.

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The Lessons of Vietnam—Part III

SAIGON

THE FACT THAT THE PENTAGON was not well prepared to fight a war like Vietnam cannot be blamed solely upon its civilian leadership. The military itself, and in particular the Air Force, must share a substantial part of the blame.

The Air Force neglect of the tactical area is evident. The principal Air Force fighter in use in South Vietnam, the F-4, was developed by the Navy. Air Force air-to-air and air-to-surface missiles, *Sidewinder* and *Bullpup,* were developed by the Navy. The follow-on Air Force tactical fighter, the A-7, is being developed by the Navy. The follow-on Air Force air-to-surface missile, *Walleye,* is being developed by the Navy. The Air Force follow-on forward air control aircraft, COIN, is being developed by the Navy for the Marines.

How did this situation develop? One cause was the squabble over roles and missions in which vociferous Air Force claims to the tactical air support role obscured the fact that it was developing no equipment to carry out the task. Another was the quite necessary Air Force concentration on the strategic role which resulted in almost total neglect of tactical airpower.

Far more of the blame, however, can be attributed to the lack of guts of many career officers in the service. Although disagreeing strongly with hardware decisions made by upper-echelon Dept. of Defense civilians, they made no protest, choosing the safety of a comfortable career berth in preference to the possibly harsh penalties which might arise from standing up for their beliefs.

You can find them today behind their desks in the Pentagon, fearful of speaking their minds because it might upset their civilian superiors. Docilely, they accept restrictions on their meetings with the press, their public utterances and their testimony before Congress. They have been effectively muffled because they have been afraid to fight.

There is today no Billy Mitchell to say "I told you so" in regard to neglect of tactical developments. No such man arose when he was needed.

Conformity is the creed; mediocrity is the result.

The fact that some new weapon systems are under development is no excuse. They could and should have been ready for use in Vietnam today, not next year or the year after. They were not because the Secretary of Defense did not believe the U.S. would be in this war and the military men around him did not insist that the equipment had to be ready regardless of his optimism.

As we have said before, the U.S. must always be ready to fight today's war with today's weapons. The best weapons system possible is the one that should be available. This is true even if it must be thrown away and replaced wthout ever being used in battle.

But when there is no war, the temptation is always to postpone the production decision in order to obtain that extra benefit which tomorrow's design will bring. That is the path down which the extreme cost-consciousness of the Pentagon has led. As a result, the war in Vietnam is being fought largely with yesterday's weapons.

However, one of the truly impressive facts of the war here is the extreme competence with which these weapons are being used. The Air Force and the Army have evolved a close air support system which, while not perfect, has brought a complete reversal of the bitter situation which existed in Korea.

The unwarranted criticism of Air Force close support by a Congressional subcommittee headed by an ex-Marine was received with shock and dismay in Saigon, by the Army as well as by the Air Force.

THIS EFFECTIVE USE OF AIRPOWER has amply demonstrated what advanced technology can mean in conflict with a guerrilla force. Despite the difficulties inherent in body count of kills from the air, air action nevertheless is credited with some 23,000 Viet Cong killed last year, far more than killed by ground forces.

Airpower has thrown off, and indeed reversed, the Viet Cong timetable for the takeover of South Vietnam. When no longer able to assemble safely in the large, organized units of the classic Communist Phase III action, the Viet Cong must revert to the pure guerrilla tactics of Phase II. Recent events in South Vietnam suggest that this already is happening.

This successful use of airpower, however, should not be permitted to overshadow the major role of the ground forces; it is, in fact, the coordination between ground and air that is making both more effective.

On the Navy side, the carriers in the South China Sea are proving daily that there is a strong need for carrier aviation in limited-war situations. When study of tactical deterrence becomes as widespread as that of strategic deterrence, the future of the carrier may appear even brighter. The nuclear carrier Enterprise has fully demonstrated the advantages of nuclear power in this situation.

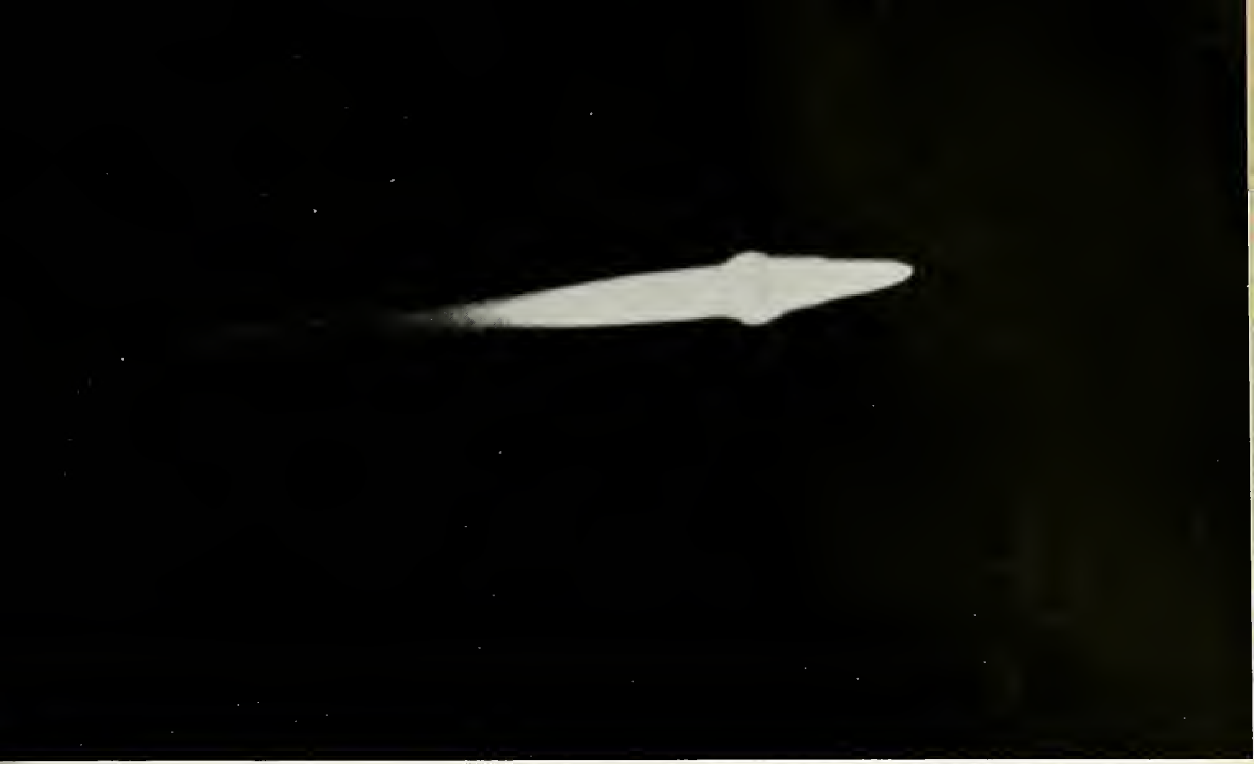
The competence of the U.S. force throughout Vietnam suggests, in fact, that this is the time for a wide-ranging study of what advanced technology really can mean to tactical warfare—not just in such terms as improving aircraft for the close-support mission but addressed to such broad questions as whether something other than an aircraft might be better.

For if the U.S. military can do such a fine job in Vietnam with limited application of advanced technology, its potential in tactical warfare when properly equipped is awesome.

But to realize that potential, the military must reassert itself in the decision-making process.

(Third of a series)

William J. Coughlin



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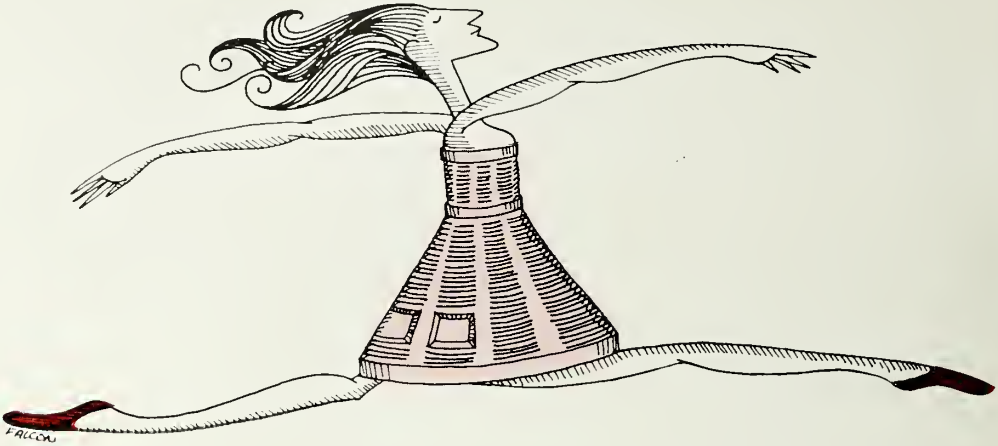

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missiles and rockets

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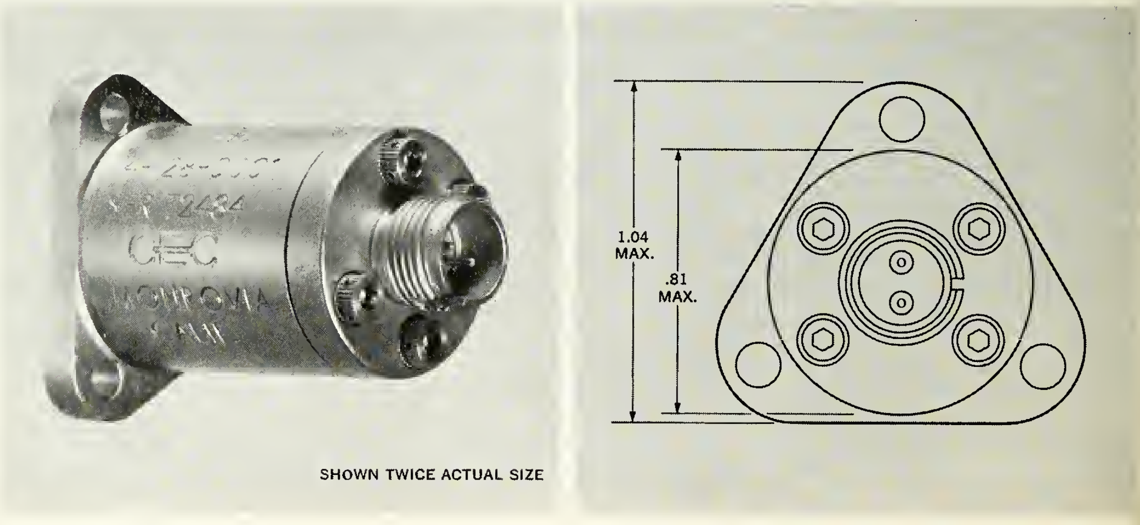
MOTION MEASUREMENT REPORT CEC

REPORT NUMBER 5

New high-temperature vibration transducer eliminates weight problem



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SCIENCE/SCOPE

A communications-satellite ground station just completed at Caddo Gap, Arkansas will enable Hughes scientists to begin long-range experiments in space communications completely independent of commercial requirements. Built and operated with company funds, the $2-million station includes an 85-foot dish antenna capable of maintaining contact with satellites over both the Atlantic and Pacific Oceans.

First F-111B to test the Navy's new Phoenix missile landed at the 9,000-foot Hughes runway at Culver City, Calif. in early April for installation of the system. The latest in a long line of advanced airborne weapons systems, the Phoenix was brought in below the minimum size and weight prescribed by the Navy. The Phoenix mission: maintain air superiority over distant objects (beachhead landings) as well as Navy fleets in anti-air warfare.

The attenuated radio signals received from space can now be boosted by a high-power (8-10 kw) traveling-wave tube recently developed by Hughes for ground-station amplifiers. It's the first commercially available tube that can replace klystrons and that can cover the entire communications band. It carries a 2,000-hour warranty, too.

A laser rangefinder, designed for low-flying fighters, has been successfully tested at Eglin AFB. It solves a problem that has long plagued microwave radar systems: their returns get lost in ground clutter at the small grazing angles encountered in low-altitude penetration. The recent USAF tests indicate that the new laser system will definitely improve weapon-delivery accuracy.

Our new Missile Systems Division will combine all Hughes missile activities in one plant at Canoga Park, Calif. The Canoga Park force, planned for more than a thousand, is growing daily. Current programs include the Phoenix missile for the F-111B, the TOW anti-tank missile, and the AIM-4D, GAR-11, HM-55, HM-58, and other members of the Falcon missile family.

100% increase in engineering staff. Latest count at Hughes shows that one employee out of four is either a scientist or an engineer (just six years ago it was only one in eight). And the need continues to increase. So if you're interested in the advanced programs at Hughes (and the good life in Southern California), just write: Mr. D. A. Bowdoin, Hughes Aircraft Co., Culver City, Calif. An equal opportunity employer.

The GIs have a new combat radio that won't be easy to jam: a transistorized, single-sideband, two-way radio with 10,000 individual voice channels. Dubbed Manpack, it's the size of an attache case and weighs only 29 pounds. Manpack bounces its high-frequency signals off the ionosphere, which gives them far greater range than the line-of-sight signals of previous combat radios. Units communicated easily at over 500 miles in recent jungle-terrain tests. Another advantage: Manpack operates as efficiently on flashlight batteries as it does on wet cells. Hughes is producing Manpack for the U.S. Army.

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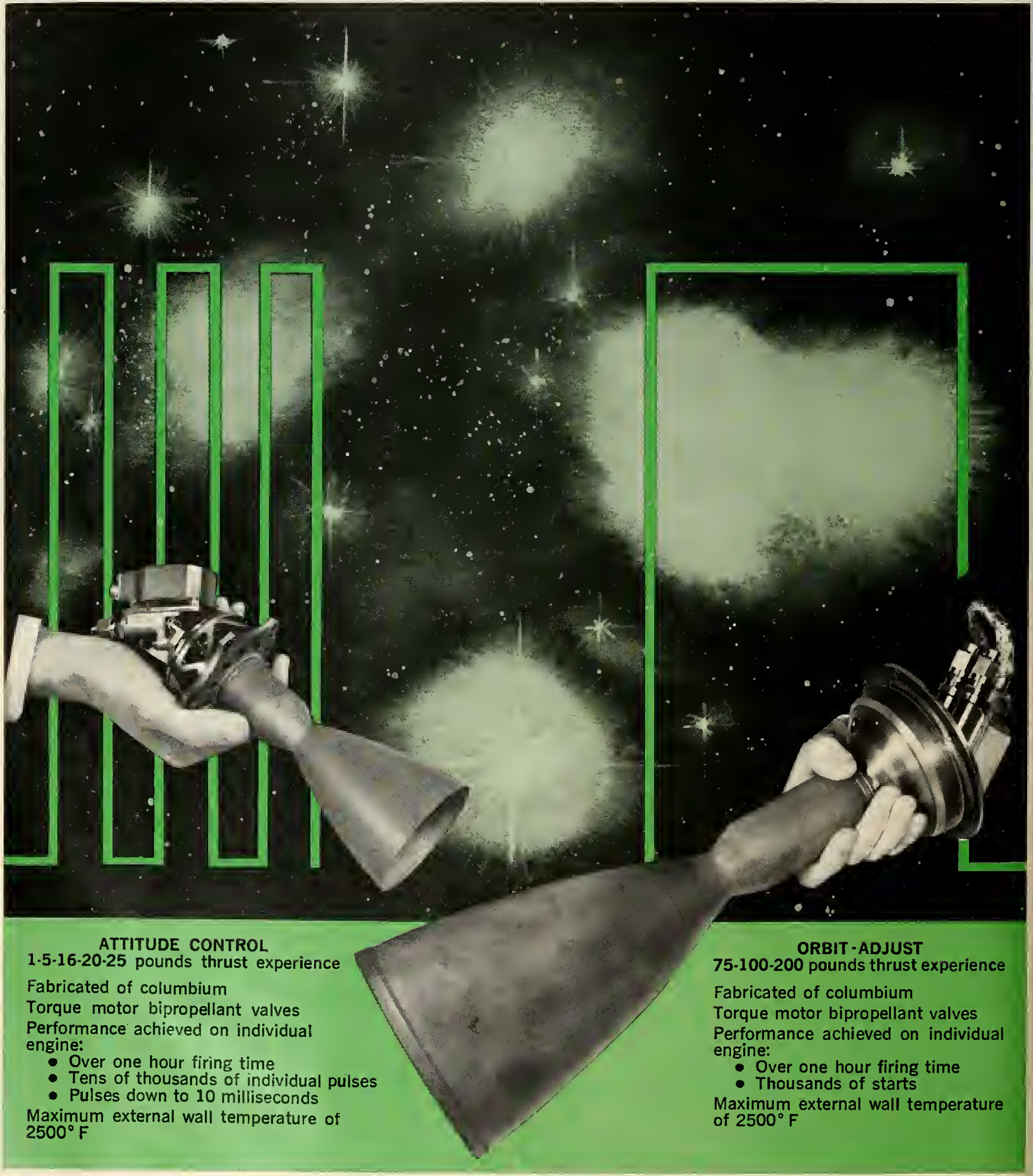

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missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

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THE COVER

Model of the HL-10 lifting body re-entry vehicle is shown being investigated in NASA/Langley Research Center wind tunnel in this Schlieren photograph. Speeds in tests ranged from Mach 1.5 to Mach 2.8. Martin has won HL-10 Langley study contract. (See p. 10.)

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Memo from the Publisher

New York Editor Ron Barnhart (standing) and Managing Editor Reed Bundy.

One of the most important geographical areas of our editorial coverage centers around New York City. It reaches north into New England, south toward Philadelphia, west to upstate New York and east to Long Island. It covers such diverse facilities as the Electronics Research Center and electronics complex of the Boston area, the General Electric Valley Forge Space Technology Center, Curtiss-Wright in New Jersey, Textron's Bell Aerosystems Co. in Buffalo and Grumman Aircraft Engineering Corp. at Bethpage, L.I., in addition to many others.

It takes a man with endurance, technical knowledge and outstanding editorial ability to cover this major segment of our industry. We are pleased to announce we have found such a man. Just appointed New York bureau chief for MISSILES AND ROCKETS is Ronald G. Barnhart, who comes to us from Thiokol Chemical Corp. in Ogden, Utah, where he headed the Astro-Met Division's publications department.

Before joining Thiokol, Ron, shown above with M/R Managing Editor Reed Bundy, was employed as chief proposal writer in the research and development department of Martin-Orlando and worked on the *Sprint* missile proposal. Prior to that, he was senior technical writer in the R&D department of Texas Instruments' Apparatus Division in Dallas.

With that background, Ron is no stranger to spectrum analyzers, parametric amplifiers, lasers, radar and sonar systems, sounding rockets, ground support equipment or the many other components which make up today's aerospace systems.

His journalistic experience includes a year on the Stillwater, Oklahoma, *Daily News Press* and his military service was as a radar-systems repairman. He has a B.A. in English literature from Oklahoma State University and has completed courses in mathematics, physics and electronics at Southern Methodist and Utah State.

Our Mr. Barnhart, as you can see, has just that rare combination of journalistic background and technical experience which is so valuable in an M/R editor. His wife, Suzanne, and their three children will be joining him soon in New York.

We are pleased to have Ron aboard. Those of you in the New York area will be seeing a lot of him in the days ahead. Those of you everywhere will be seeing a lot of his by-lined articles—more of the experienced, accurate reporting which is a MISSILES AND ROCKETS hallmark.

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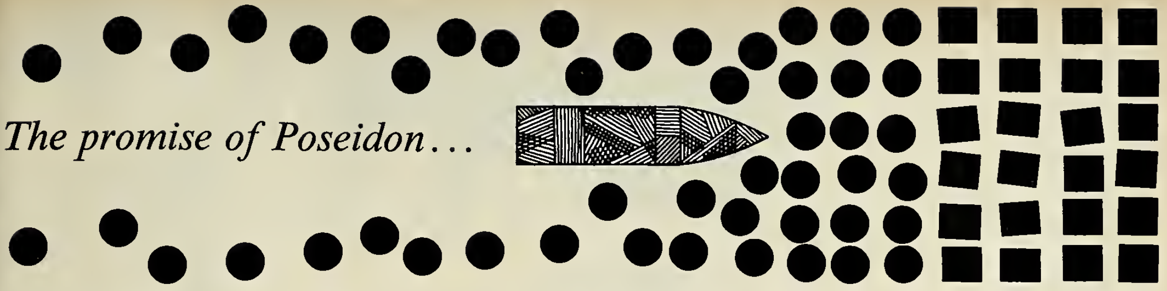
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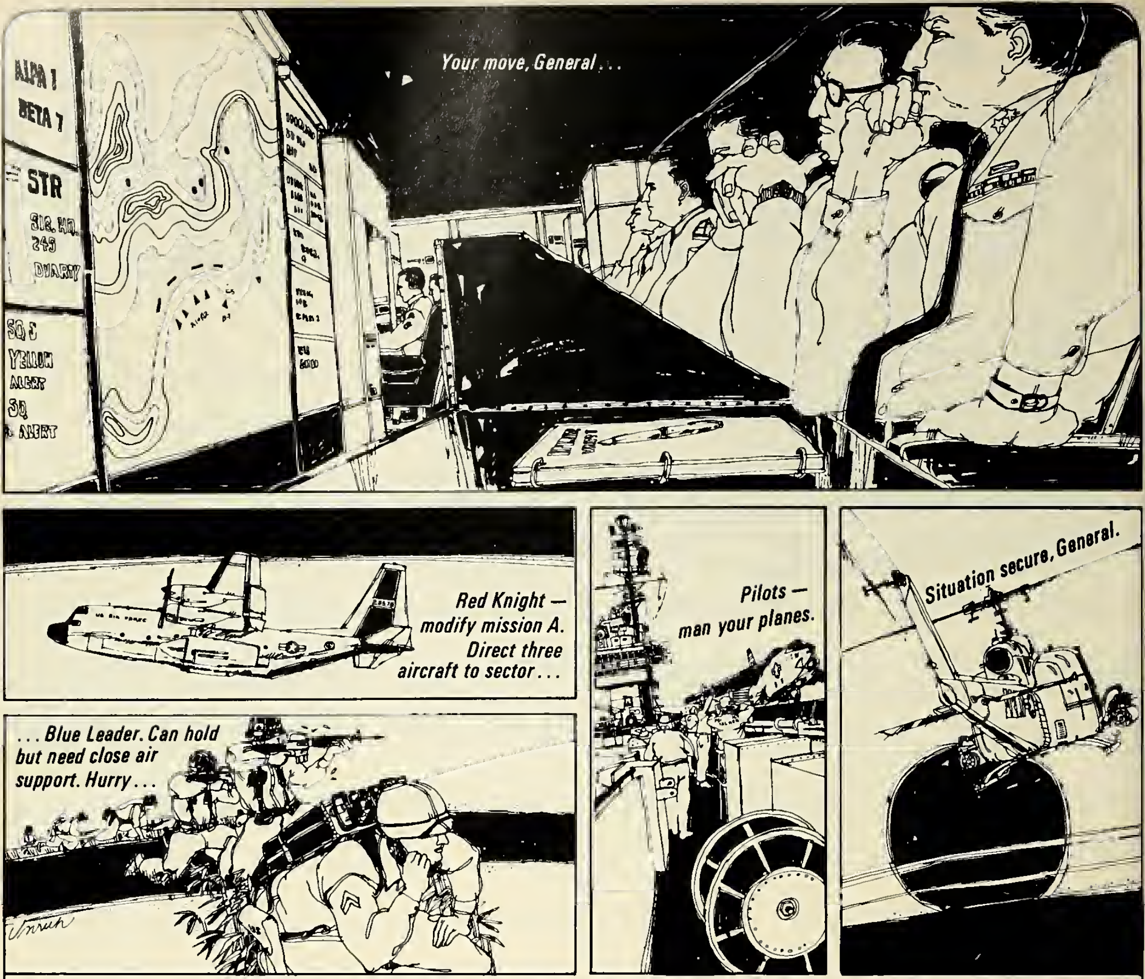
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The Countdown

WASHINGTON

DOD Looks at Added Agena Propulsion

Dept. of Defense is considering possible addition of a small new propulsion system to the *Agena* spacecraft to give it improved maneuverability for future missions in near-Earth orbit.

Congress May Take Up H-Bomb Hunt

Search and recovery of the missing H-bomb off the coast of Palomares, Spain, may be discussed on the House floor this week by Rep. Paul Rogers (D-Fla.), who has been gathering data on the operation. A member of the oceanographic subcommittee of the House Merchant Marine and Fisheries Committee, Rogers long has revealed a keen interest in all aspects of the U.S. oceanology effort.

LOH Award Under Hill Scrutiny

A Congressional committee is looking hard at circumstances surrounding award of the Army contract for the Light Observation Helicopter to Hughes Aircraft Co. While the Hughes bid was by far the lower, committee members suspect additional costs are running the contract well above the original bids. A Hughes spokesman flatly denies any implications of under-bidding the contract.

First Break on Oceanology Bill

Senate conferees on S-994, Sen. Warren G. Magnuson's oceanology bill, have been named in the first step toward agreement on the legislation. They are Senators Magnuson (D-Wash.), John O. Pastore (D-R.I.), E. L. Bartlett (D-Alaska), Daniel B. Brewster (D-Md.), Norris Cotton (R-N.H.) and Thruston B. Morton (R-Ky.). Announcement of their House counterparts is expected sometime this week.

Approval for New NASA Computer Seen

NASA Headquarters is expected to give approval late this month to a Marshall Space Flight Center proposal for procurement of a third-generation computer system. The plan calls for replacement of almost all of the MSFC computers. Requests for proposals on the multimillion-dollar contract will be issued by Marshall as soon as Headquarters approval is received.

INDUSTRY

TI Gets Laser Missile Study

Army Missile Command's long-term interest in use of lasers for air-to-surface missile guidance is behind a new MICOM-supported study by Texas Instruments. TI will investigate use of a ground-based laser system to illuminate targets for a missile equipped with a seeker which can home on the reflected radiation. Study, which may take a year, will involve the TI-built *Shrike* anti-radiation missile. This will be primarily as a test vehicle but could evolve into an operational system, according to sources close to the project. No flight hardware will be built in the early study phase.

Phoenix/F-111B Mating Starts at Hughes

Navy/Hughes *Phoenix* air-to-air missile system is being mated to an F-111B aircraft at the Hughes Culver City, Calif., facility. First drop tests and missile control system checkouts are slated to begin at Pt. Mugu, Calif., this fall. First guided flights are to begin early next year. F-111B will carry six 1,000-lb. *Phoenix* missiles. Aircraft is said to be still 4,000 lbs. overweight, none of which is attributed to the missile system.

Servo Corp. Gets Shrike Subcontract

Servodynamics Div. of Servo Corp. of America will develop the RF portion of the automatic checkout system for the guidance section of the *Shrike* anti-radiation missile. Contract, valued initially at $100,000, is from Sperry Farragut Div. of Sperry Rand. Work on the system will be carried out at Servo's Hicksville, N.Y., facilities and at Sperry Farragut in Bristol, Tenn.

Avco To Start Mk 17 Production

Avco's Missile System Div. will complete development and begin production of the Mk 17 re-entry vehicle for *Minuteman II* under a new Air Force Systems Command contract expected to be worth $63.5 million in total funding. Production of the vehicle will be concentrated at Avco's Lycoming Div. in Stratford, Conn. Sources close to the *Minuteman* program tell COUNTDOWN that the first Mk 17 will not be delivered for another 2½ years, with final delivery slated for mid-1970. Mk 17 and the General Electric-built Mk 12, now in production, will make up the mixed *Minuteman II* force. Still undisclosed by DOD is identity of the *Minuteman III* re-entry vehicle to be procured for the first time in FY '67. It is not the Mk 17, say project sources.

De Havilland To Provide Rigid Tether

De Havilland Aircraft of Canada Ltd., designers of retractable, pre-stressed coil springs which pop up into antenna booms or probes, will fabricate an extendable 20-ft. boom to serve as a rigid tether during crew transfer operations in space. NASA's Manned Spacecraft Center initiated development under a $144,747 contract calling for delivery by June of this year. The retractable booms will be standard equipment on all Block II *Apollo* Command Modules.

Mission Control Gets Faster IBM's

Mission Control Center's real-time computer complex 7094 computers gradually are being replaced by IBM's bigger and faster 360's (model 75) to handle data during the *Apollo* manned missions. First of four IBM 360's has already been delivered to the Manned Spacecraft Center and all four are to be ready early in the *Apollo* manned flight program.

INTERNATIONAL

French Lasers Light GEOS A

The *GEOS A* satellite, launched last Nov. 6, was the target of laser beams emitted by the St. Michel de Provence observatory of France during the first quarter of 1966. Some 600 echoes were recorded in this period. Of these, 108 were during a single fly-over on Jan. 12. The 50-megawatt solid laser used for the experiment was built by the Laboratory of CGE at Marcoussis. Measurements obtained are said to have a 6-7 ft. accuracy.

Japanese Defense Agency Seeks Build-up

Japanese Defense Agency plans to ask for an appropriation of $7.5 billion—1.3% of the estimated national income—for FY '67, first year in Japan's third five-year defense build-up program. Budget is aimed at increased military preparedness with conventional weapons, including *Nike-Hercules* and *Hawk* missiles (M/R, Jan. 24, p. 9).

Domestic TV Satellites Foreseen

A communication satellite system for domestic television distribution is considered possible within the next 3½ years with an initial investment of approximately $100 million.

Results of two separate studies to develop a configuration for such a system were presented last week at a meeting sponsored by the Communications Satellite Corp. Attending were about 100 representatives from the broadcasting, communications and manufacturing industries and various Government agencies.

An approach presented by Comsat called for two synchronous satellites, providing some 15 to 20 television channels each, with two more satellites in orbit for stand-by purposes. The spacecraft would provide five channels in each of the four time zones, with extra channels available for special requirements.

The system would involve 86 initial ground stations serving the 100 major metropolitan areas. This number would ultimately grow to 225 stations to serve the present television stations.

Initial investment of the Comsat system was estimated at $100 million with an annual cost of $25 to $35 million.

A configuration presented by National Broadcasting Co., resulting from a study by Radio Corp. of America's Astro-Electronics Div., called for a six-satellite system with three channels per satellite to serve a four-network setup. Under the plan, a ground station would be located near each television station involved.

NBC estimated initial investment at $103.4 million and annual costs of $19.4 million, amortized over a 15-year period.

Martin Wins Re-Entry Study

Martin Co. has been selected by NASA to study the cost and complexity of a flight research program using a manned lifting-body vehicle.

Together with the firm's selection as prime contractor in the Air Force's PILOT program (M/R, April 11, p. 14), the two contracts could give Martin the lead over competitors in development of lifting body technology.

The PILOT contract, valued at $1 million, calls for development of the Piloted Low-speed Test Re-entry vehicle. It is part of the START (Spacecraft Technology and Advanced Re-entry Test) program.

The NASA study contract will be negotiated with Martin by Langley Research Center. It is expected to cost about $450,000.

In conducting the study, the firm is required to consider an HL-10 lifting-body concept capable of carrying one, two, four, six or eight crew members. The HL-10 is considered representative of advanced lifting entry vehicles.

NASA has specified *Titan II*, *Titan III* and *Saturn IB* as potential launch vehicles. For the study purposes, the Rogers Dry Lake at Edwards AFB, Calif., location of NASA's Flight Research Center, would be a probable landing site.

AF Awards SABRE Contracts

Dual contracts have been awarded North American Aviation's Autonetics Div. and General Motors' AC Electronics Div. for work on the SABRE (Self Aligning Boost and Re-entry) guidance system (M/R, March 21, p. 7).

The Air Force contracts cover design, development, prototype fabrication and testing of the system. Interim funding is approximately $650,000 for each contractor. The system is considered one of the keys to advanced ICBM design.

AC-8, OAO Flights Fail

NASA officials do not believe the recent unsuccessful flights of *Atlas-Centaur 8* and the *Orbiting Astronomical Observatory* will affect the launch schedule of the next flights of the space vehicles.

The *Centaur* is expected to send the first *Surveyor* spacecraft on its way to the Moon late in May. The next flight in the *OAO* series is not scheduled until mid-1967, so the problem of what caused the spacecraft's batteries to heat up on April 8 with the resultant loss of power should be solved by then.

On April 7, the *Centaur* mission failed when the two RL-10 upper-stage engines failed to re-ignite while in Earth orbit. During the *Surveyor* mission, the *Centaur* engines will be fired only in the boost phase and will not be required to restart. Since this has already been done several times, the *Surveyor* mission should go off on schedule.

OAO was launched April 8 after five previous attempts. Firing in flight was nominal and, up until the time the spacecraft batteries overheated, the flight looked flawless.

Centaur went through four scrubs before the successful final try on April 7. Again, the flight was nominal until the failure of the *Centaur's* second ignition.

Planet Fly-by Study Sought

Technical guidelines for the one-year study of manned Mars/Venus fly-by missions state that only *Saturn V/Apollo* hardware is to be considered.

Marshall Space Flight Center released the RFP for the study to some 33 firms earlier this month; responses are due May 10.

The winning contractor will be asked to determine if useful data can be obtained from a manned fly-by and what probes should be launched as the spacecraft passes a planet. Only *Saturn V* and uprated versions of the launch vehicle expected to be available in the 1970's are to be considered in the study. The spacecraft will use the basic *Apollo* plus such developments as can be reasonably anticipated with 1970 state of the art.

Output of the study will consist of a detailed mission description for each launch opportunity, identification of all Earth-based operations, definition of the entire fly-by system, a description of all experiments, analyses of alternate missions in terms of needs and relative disadvantages, an assessment of the utility of the mission, both as a forerunner to manned landings and as a scientific quest in itself, and development schedules and total costs.

Apollo Funds Eyed for ABM

A high-ranking member of the House Appropriations and Armed Services Committees has questioned whether money spent to put a man on the Moon should instead go to an anti-ballistic missile defense system.

Rep. Robert Sikes (D-Fla.) voiced growing apprehension about the progress of the Soviets in the anti-ballistic missile defense field, pointing out that the USSR may be the only country to have an ABM.

Pointing out that cost of an anti-ballistic missile defense is estimated at about $20 to $30 billion, the same amount the U.S. is spending for the manned lunar landing program, he questioned which program is more important to the survival of America.

Shots of the Week

The much-delayed launches of *Atlas-Centaur 8* and the *Orbiting Astronomical Observatory* were completed from Cape Kennedy on April 7 and 8, respectively. (See p. 10.)

- A *Polaris A-3* was destroyed in flight April 7 after a successful launch from the USS George Bancroft. The missile apparently veered off course two minutes after being fired from the submarine, submerged off the coast of Cape Kennedy. A second *A-3*, fired from the sub 30 minutes later, had a successful flight downrange.
- The French successfully fired a *Saphir* rocket from the African Hammaguir missile range on April 5. It was the eleventh successful launch for the vehicle's *Emeraude* first stage.

GAO Restrictions Criticized

Two more Congressmen have criticized the House Government Operations Committee for its recommendations concerning General Accounting Office treatment of defense contract audits.

Rep. Richard H. Poff (R-Va.) and Rep. James A. Haley (D-Fla.) disagreed with the committee in chastising the GAO for its handling of audit reports, including the numbers and language of the reports themselves (M/R, March 28, p. 26).

Haley called for a public outcry against the committee, which he charged with trying to "diminish GAO's effectiveness and cover up information the public has a right to know."

Poff said that he did not approve any effort on the part of Congress "to gag and sterilize" its own investigative arm, especially when the same political party has such big majorities in both executive and legislative branches of the Government.

Lunar Orbiter Launch Set

Current plans call for the first *Lunar Orbiter* to be launched from Cape Kennedy the weekend of July 9-10, NASA officials have announced.

Delivery of the vehicle to NASA is slated for June 20. Delivery was originally scheduled for May 11, but was pushed back because of *Surveyor* slippages.

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Lockheed Choice to Build First DSRV

WASHINGTON—Lockheed Missiles & Space Co., Sunnyvale, Calif., has won the contract to build the Navy's prototype deep-submergence rescue vehicle (DSRV).

Announcement of the prototype development contract, probably one of the most important in the oceanology field, is expected shortly. LMSC and Navy are said to be negotiating details of the award, which will total $5-6 million—one of the largest hardware contracts ever let for an oceanological project.

The first solid indication that LMSC was on the inside for the contract was the visit last week by Samuel Feldman, head of the Navy team evaluating the proposals for the prototype DSRV, to the Sunnyvale facility. Lockheed was the only company Feldman visited.

Two other companies, the Electric Boat Div. of General Dynamics Corp. and North American Aviation's Autonetics Div., submitted bids on the prototype rescue vehicle last Dec. 20.

The contract award will be the first major step in development of the Navy's undersea search and rescue fleet. It also will focus attention again on the overall Deep Submergence Systems Project (DSSP) program, regarded by many as an effort which one day will have far-reaching national impact.

Five more in works—Current DSSP plans call for five operational DSRV's following the development of one prototype. Planned for operational depths of 6,000 ft., the vehicles will be used for deep-sea research at various locations when not otherwise engaged. The prototype rescue vehicle is expected to have a depth limitation of about 3,500 ft.

One source indicates that the program will be held to one operational vehicle during Fiscal Year 1968 because of funding limitations. Requests for proposals for the program will be competitive, but are not expected for another year.

Funding limitations also may delay the development of the deep search vehicle, to be designed for operations to 20,000 ft. Plans for this program call for one prototype submarine with a 6,000-ft. operating capability and four operational vehicles with a 20,000-ft.-depth limitation.

Its work on Deep Quest, an undersea research vehicle now in construction, obviously gave LMSC the edge in bidding for the DSRV prototype. A large deep submersible, Deep Quest has been built largely in conformance with the requirements laid down by DSSP for its rescue vehicles. It will be second only to the Reynolds International Aluminaut in submerged endurance, have a 7,000-lb. wet payload and be able to operate at the same 6,000-ft. depth planned for the DSRV's.

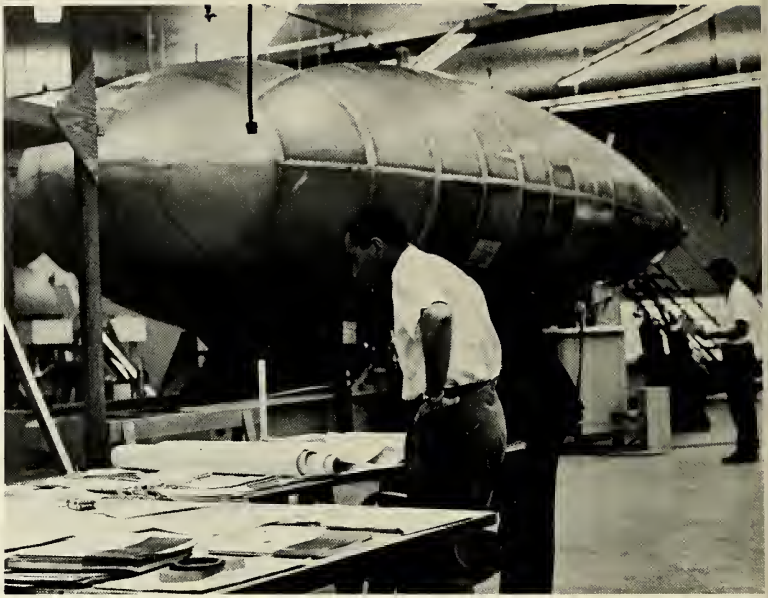
Apparently no major modifications or expansion at the Sunnyvale facility will be required for performance of the DSRV contract. Work on the prototype rescue vehicle can be accomplished in the same area of the building where Deep Quest is under construction.

Deep Quest is scheduled for its first operations in the fall and the Lockheed Marine Laboratory at San Diego is already being developed for this purpose. The facility will be well suited to DSRV prototype operations when they begin in about two years.

Expansion—The facility, on Harbor Road near the San Diego airport, now consists of 2.7 acres. LMSC has an option on an adjoining acre—a plot which will give it access to an inlet into San Diego harbor. An existing building at the site has about 12,000 square ft. of floor space and accommodates offices and laboratories.

The expansion plan for the site includes the construction of a 125-ft.-long pier, which will be used to handle Lockheed's research vessel, Sea Quest, as well as the supporting surface vessel for Deep Quest. Installation of 150 ft. of railroad track, most of which will be underwater, will accommodate the cradle to carry Deep Quest into the water. Local authorities are now dredging the inlet for the track installation.

Also planned is the construction of another building at the site which will add another 10,000 to 15,000 ft. of floor space, much of which will serve as a "hangar" for the vehicle. Cranes capable of lifting 50 tons will be installed. These should easily handle all the lifting requirements for the DSRV prototype. ■



Hull for Deep Quest under construction at the Sunnyvale, Calif. plant of Lockheed Missiles & Space Co. LMSC's work on Deep Quest was probably instrumental in winning the Navy contract for the prototype deep-submergence rescue vehicle.

Navy Confirms Choice of Island as Sealab III Site

SEALAB III will be conducted off San Clemente Island near San Diego, Calif. Confirmation of the site for this third Navy experiment of living in and working from a habitat on the ocean floor came in a memorandum from a Navy Department official to Sen. Warren G. Magnuson (D-Wash.)

The memorandum came after the belated bid by Seattle-area oceanography groups to obtain the Sealab III program for Puget Sound. The Sealab II program was also conducted in the Pacific Ocean, off the coast of La Jolla, Calif.

NASA Ponders Pioneer Shot to Venus

by Hal Taylor

WASHINGTON—The space agency is considering a plan to use the *Pioneer* spacecraft to explore Venus.

The *Pioneer* probe conceivably could replace the *Mariner* 1967 Venus shot if Congress fails to approve funds for that mission.

The unsolicited proposal from TRW Systems Group was presented to Associate Administrator for Space Sciences and Application Homer E. Newell on April 6. Later, TRW officials also briefed staff members of the House Space Committee's Space Science Subcommittee.

NASA officials refused to say whether the proposal will be approved, but they admitted that it was under consideration.

The project would add a sixth spacecraft to the *Pioneer* program. The development time would be 18 months and the total cost, including the launch vehicle, would be $10 million.

Officials report that the *Venus/Pioneer* flight is not designed as a replacement for the *Mariner* spacecraft fly-by of the red planet in 1967. That program, with an estimated cost of $30 million, has already been approved by high-level space agency officials.

The House Space Committee, however, in final action on NASA's FY '67 budget request refused to vote funds for the *Mariner* shot. If the Senate Space Committee goes along with the action and kills the *Mariner* program, it may be possible for NASA to substitute the *Pioneer* probe and still get much of the scientific information it wants.

Advantages—Supporters of the *Pioneer* shot report that it is simply a follow-on to the current five-flight *Pioneer* series and that it should be approved no matter what fate awaits *Mariner*.

The major advantage of the *Pioneer* flight, they report, is that it would not be restricted to a launch during the approximately two-year Venus launch opportunity—primarily because it would use the planet's gravity to pull it in close to the surface during its swing-by of the planet. After swinging past and behind Venus, the spacecraft would go into solar orbit.

They maintain that it could come within 5,000 to 10,000 mi. of the planet and carry experiments designed to provide good data on its magnetic field and atmospheric pressure.

Pioneer lends itself to the magnetic experiment because it is clean of any magnetism. An occultation measurement of the atmospheric pressure could be included if some communications equipment were added to the spacecraft.

Very few changes would be required in the current spacecraft, supporters of the project say. The only major change would be the addition of a propulsion system to provide a mid-course guidance correction capability. This would involve the addition of three bottles containing hydrazine. Automatic controls for the system would also be needed.

The weight of the spacecraft would stay even or rise slightly above the current 140-lb. payload. It would be boosted on the long mission by the *Thrust-Augmented Delta (TAD)* launch vehicle.

Nearer Venus—Current NASA plans for the 1967 mission call for the flight spacecraft which backed up the highly successful *Mariner IV* mission to Mars in 1965 to be modified for launch to Venus in mid-year. The spacecraft, to be launched by an *Atlas-Agena*, will take about three to four months to reach Venus. The scientific experiments will be improved versions of those flown on previous *Mariners*. The *Mariner* will be aimed to fly closer to Venus than 21,600-mi. approach to the planet made by *Mariner II* in 1962 after a 109-day journey. ■

AAP Definition Awards Weeks Away

SELECTION of contractors for systems definition in the *Apollo* Applications Program (AAP) is expected in about two to three weeks.

Announcement of the awards could be delayed even longer if top NASA management delays its approval of the recommendations of the Marshall Space Flight Center.

At the same time, it was learned that the agency has told the House Space Committee that the AAP will require $1 billion in new funding in Fiscal Year 1968.

The agency said $700 million of the funds will be used to maintain the production capability and mission-support capability being developed in the *Apollo* program. The balance will be used to develop flight experiment hardware, extend the spacecraft capability, and integrate the experiments with the vehicle.

In addition, Manned Space Flight will need $328 million for administrative operations expenses.

As for the systems definition contract, it is expected that the space agency will select at least two firms for a parallel effort. Part of the definition work will include the preparation of estimates of the cost of the actual system integration of the experiments and the spacecraft, as well as any required new hardware development.

The Marshall contract will cover only integration of the experiments into the Lunar Excursion Module (LEM). This, however, represents the vast majority of space available for experiments.

The integration of experiments into the Command and Service Modules will be directed by the Manned Spacecraft Center. Earlier, it was believed that NASA would also decide to have a separate contractor selected by MSC physically mate the experiments into the two modules.

This plan has now been dropped and it is expected that the firm named to develop the *Apollo* Experimental Pallet—which will be placed in the Service Module—will also be responsible for the payload integration.

Four firms—Lockheed, McDonnell, Martin and Northrop—are expected to submit their written proposals to MSC on April 22. The winning firm is expected to be named three to four weeks later.

Experiments picked—As the space agency moved to initiate systems definition of AAP, it also revealed the selection of the first three experiments which have been approved for flights in the program. The three experiments which are expected to move into the hardware development phase shortly are Lunar Mapping Photography, Low Z Cosmic Ray and High Z Cosmic Ray.

It was also learned that another 150 experiments have been approved to move into the systems definition phase. All of them will be funded with money from the FY '66 and FY '67 budgets.

Approval of the experiments for the program is being handled by the Manned Space Flight Experiment Board. The experiments have been proposed by individuals, universities, industrial firms, and Government R&D centers.

Dr. George E. Mueller, Associate Administrator for Manned Spaceflight, is chairman of the board.

New Titan III-C Procurement Planned

by Michael Getler

WASHINGTON—Air Force and Defense Department are preparing a follow-on production plan for additional *Titan III-C* launch vehicles, according to Dr. John S. Foster, Jr., Director of Defense Research and Engineering.

Foster reports that the vehicles will be used primarily to launch new military communications satellites associated with the Advanced Defense Communications Satellite Program (ADCSP) and tactical communications satellite programs.

Consideration is also being given, Foster reports, to additional *Titan III-C* vehicles for future replenishment launchings of satellites for the Initial Defense Communications Satellite Program (IDSCP) beyond those already planned and for more flights of *Nuclear Detection Satellites* and new multiple-engineering payloads.

Air Force sources say current studies of additional *Titan III-C* procurement are to be completed this fall in time for inclusion in the Fiscal Year 1968 budget request. Various procurement plans are being studied, initially involving three to eight new boosters, according to Air Force officers.

The number of boosters is tied to DOD approval of some of the follow-on satellite programs, such as the tactical comsat network (M/R, Jan. 31, p. 58), and the individual cost is linked to both the launch and production rates. Officers estimate cost of the individual *Titan III-C's* at between $13 and $20 million each, including launch costs.

The new launch vehicles will be in addition to the remaining 10 *Titan III-C* R&D boosters still in the Air Force inventory and already committed to launch assignments. All of the *Titan III-C* launchings will be from the Eastern Test Range (ETR).

Foster made his remarks before the Senate Committee on Aeronautical and Space Sciences in a special hearing called to investigate the Air Force's decision to build new launch facilities for the *Manned Orbiting Laboratory* (*MOL*) program at the Western Test Range (WTR) rather than expand the existing *Titan III-C* facilities at Cape Kennedy to handle the larger seven-segment version of *Titan*, which will launch the *MOL*.

The hearings were called at the request of Sen. Spessard L. Holland (D-Fla.), a member of the committee.

Critics quashed—In defending the launch area decision against charges, mostly from Florida-based interests, of costly duplication of facilities (M/R, Jan. 17, p. 9; Feb. 21, p. 9), of juggling payload figures and orbital requirements, and of Air Force skulduggery in moving the *MOL* project behind the much more secure confines of Vandenberg AFB complex, both Foster and Dr. Robert C. Seamans, Jr., Deputy NASA Administrator, strongly backed the Air Force.

Foster stated flatly that "the program requires that the vehicle be launched into a polar orbit," that "land overflight during the launch phase must be avoided," and that "the seven-segment *Titan III-C* cannot deliver the required payload weight from ETR using a 'dog leg' trajectory."

The dog leg, in this case, would be achieved by launching eastward from the Cape and then turning the vehicle south during ascent. This pattern, while cutting the useful payload that could be lofted into polar orbit with a direct launch due south from the Cape, avoids an overflight of the heavily populated southern Florida area.

However, even with the dog leg to avoid the Florida coast, the *MOL* would still pass over Cuba and Central America during the pre-orbital stage. DOD, the Air Force, and the State Department say that the risk of losing a highly classified payload and astronauts over these areas is not worth taking.

The estimated *MOL* payload weight is about 30,000 lbs., and it is this weight that the seven-segment version of *Titan* is designed to lift from WTR into polar orbit. Capability of the same booster from ETR with the requirement for a dog-leg maneuver is said to be about 27,000 lbs.

Support from Seamans—Dr. Seamans told the committee that the *Saturn IB* booster, including payload increases achieved through vehicle refinements in the past year, could deliver "a maximum of 28,000 lbs. for a polar orbit with a dog-leg maneuver." Seamans said "that compares very closely with the *Titan III* seven-segment solid."

MOL Flight Slips into '69

The first flight of an unmanned version of the Air Force's *Manned Orbiting Laboratory (MOL)* has slipped its schedule into early 1969, high-level Dept. of Defense sources told Missiles and Rockets.

The first flight, one of seven now planned for MOL through 1970, was scheduled for the last quarter of 1968 in recent DOD plans. The first two flights in the program will be unmanned, with the following five flights all carrying crews into polar orbit. Slippage of the lead-off flight is also expected to push the first manned shot beyond the mid-1969 estimate recently stated by DOD.

Seamans also said that "it does not appear that either the *Titan* or the *Saturn IB* could place the *MOL* payload into polar orbit from Cape Kennedy." The NASA scientist added that "NASA headquarters have not only supported the *MOL* program and its importance, but we have also supported the necessity of the *MOL's* launching from WTR."

Comparative costs of the two boosters revealed at the hearings indicated an $18.2-million price tag on each of the seven-segmented *Titan III* vehicles, including launch costs, based on production of six per year. Seamans said that *Saturn IB*, assuming a production rate of six per year, would cost about $35 million each. Both scientists pointed out differences in accounting procedures between agencies, and in the case of the NASA figure, cost was also linked with production rates on the larger *Saturn V* vehicle.

The hearings also pinpointed present cost estimates for the *MOL* building program at WTR, which currently involves only a single assemble-on-pad facility but which eventually will probably be expanded into an integrate-transfer-launch complex.

Cost of the WTR facility is tagged at $114 million, including roughly $80 million for ground support equipment and at least $4 million for acquisition of the Sudden Ranch property adjacent to the Vandenberg site (M/R, Jan. 10, p. 35).

Development schedules—Foster also placed the development time for the *Titan* seven-segment solid version as "a little over 2½ years" and the time needed for base facility development to "about 2½ years." Foster told the committee that facilities were not the pacing item in the project.

Ground breaking for the WTR site is expected to take place very soon. It's reported that questions of rights, if not of cost, involved in the Sudden Ranch property have now been settled.

Contract for solid motor development for the larger version of *Titan* has still not been let, although it has been expected for several months.

A spokesman for Sen. Holland told Missiles and Rockets that the Senator was apparently satisfied with the explanations offered in the hearing and that no further hearings were scheduled on the matter. ■

Third Rendezvous Added to Gemini 9

by Jinx Mercer

HOUSTON—Manned Spacecraft Center mission planners, bent hard on gaining time, have scheduled three rendezvous exercises during the *Gemini 9* mission in mid-May.

Added to the original rendezvous at third apogee and a "re-rendezvous" to evaluate a lunar mission abort procedure is a re-rendezvous left over from the abbreviated *Gemini 8* mission. MSC is anxious to get this one "in" because it rehearses the rendezvous technique *Gemini 10* pilots will use when they attempt to close in on a passive target—the *Gemini 8 Agena*.

Paul C. Kramer of MSC's flight crew operations, who, with Dean F. Grimm, has prepared pilot backup procedures and techniques for rendezvous in the event of radar, computer or platform failure, described the re-rendezvous exercises for MISSILES AND ROCKETS:

"The passive target rendezvous is very similar to a radar failure case." In the event of a radar failure, the pilot acquires the target's flashing, high-intensity xenon lights, which are visible at night from approximately 45 n. mi. Radar or visual contact with the target prior to initiating the terminal phase maneuver is "important," Kramer explained, to obtain backup data in the event the platform fails during the rendezvous.

"But with a passive target, you have no choice," he added quickly. "The target has neither a radar transponder nor lights."

Daylight rendezvous—To obtain maximum illumination of the "dead" target, Kramer explained, the rendezvous will be restricted to daylight so that the Sun will light the target during the entire terminal phase. "This necessarily shortens the rendezvous period from 130 degrees of orbital travel, used in all previous rendezvous exercises, to 80 degrees to keep the target in best lighting."

He continued: "If we used the larger angle of transfer, the Sun would be positioned directly behind the target at the start of the transfer maneuver and right in the pilots' eyes, or in good position for terminal phase initiation (TPI) but setting and placing the two vehicles in darkness just prior to braking.

"With the smaller angle, which also requires a higher energy transfer, the Sun ideally will appear directly above the spacecraft at time of TPI and will move to nearly sunset position in the sky at time of braking."

Altitude separation between the two vehicles will also be reduced, Kramer said. "Right now, we're thinking of approximately a 7-n.-mi. altitude separation for the *Gemini 10* mission. However, during *Gemini 9* simulation of the passive target rendezvous, the vehicles will be vertically displaced by only 3 n. mi. This is because we have three rendezvous exercises planned on *Gemini 9* and we're interested in conserving propellant."

Sextant on board—The *Gemini 9* crew—Thomas P. Stafford and Eugene A. Cernan—will carry a sextant on board to evaluate the instrument as a backup to both computer and platform during rendezvous without radar. Kramer said use of the sextant is somewhat limited in that the pilot must use the Earth's horizon instead of stars on the day side to make his angle measurements.

"We're assuming, based on orbital experience to date, that stars are not visible in the daytime," Kramer said.

The simulation on *Gemini 9* will be initiated from an equal-period orbit that will move the spacecraft above the target, then sweep it down through the target's altitude, and bring it into position below and behind the target at a slow catchup rate at the time TPI is made.

Pilots will be in "heads down" position relative to Earth, thus enabling them to sight upward through the sextant (a design requirement) and still obtain the Earth's horizon for making angle measurements. "Heads up" rendezvous trajectories automatically rule out use of the sextant during the day because of difficulty in sighting the horizon.

The technique, Kramer explained, is to sight with the sextant at specified times, wait for the target to superimpose on the horizon, mark the time, and read the platform angle from the computer (provided both computer and platform are operating). This mid-course measuring technique used before transfer provides the pilot with angular rate or velocity error normal to the line-of-sight during transfer.

Once the terminal phase is initiated, the pilot will make two mid-course corrections based on four angle measurements over a period of specified times. (Other backup procedures require eight measurements for four mid-course corrections, Kramer said, but the passive target rendezvous, being shorter in time period, allows for only two mid-course maneuvers.)

Radar biggest loss—Given a choice, the pilot feels loss of radar—as opposed to loss of computer or platform—makes rendezvous most difficult to accomplish, Kramer said.

The pilot loses his "feel" for his position along the trajectory without radar because his capability to correct is reduced to a single axis—to up/down components when he would prefer to correct along and normal to the line of sight.

This is not so in a computer breakdown or a platform failure, Kramer added, emphasizing that in either loss, the pilot retains a two-axis correction capability, although the correction is costly in propellant usage and slightly degraded in accuracy.

The radar provides the pilot with direct ranging capability, making it difficult—without radar—to judge closing rates immediately after the last mid-course correction and before braking.

A ranging technique, using the onboard sextant, will be evaluated during the *Gemini 9* mission, Kramer said. It consists of cranking in a setting for 20,000-ft. range, which automatically spreads the fields of view and presents a dual image to the pilot sighting through it. When the *Agenas* converge and touch end to end, the pilot marks the time, resets the range for 16,000 ft. and waits for the second time "hack." The difference in time establishes his range rate.

The ranging technique using the sextant is applicable only to a radar failure, Kramer pointed out, explaining that in either a computer or platform failure the pilot has an instantaneous range and range-rate readout from the radar analog gauge.

LEM abort simulation—The LEM abort simulation, Kramer said, is an exercise in rendezvous from above the target and against an Earth background.

After the LEM separates from the Command Module in lunar orbit, the proper phasing of the two vehicles for re-rendezvous in the event of an abort is controlled by inserting the LEM into a higher orbit. This "standard" orbit is set at 50,000 ft. (30 n. mi.) above the lunar surface.

The terminal phase of the LEM abort rendezvous is the "mirror image" of the first *Gemini 9* rendezvous, having the same closing rate, same angle/time and range/time history, and even the same angular travel (130 degrees). "The only difference is background," Kramer explained. "At TPI, the pilot will thrust along a line-of-sight (minus 27 degrees in pitch) toward the target, which will be positioned approximately 10 degrees below the rim of the Earth."

Background lighting will be minimized by scheduling the TPI maneuver shortly after sunset and gauging arrival time—before braking—for daytime shortly after sunrise. ■

Shortages Slow 2.75-in. Rocket Effort

by John F. Judge and Charles D. LaFond

WASHINGTON—An intensive effort to reach a monthly production rate of 800,000 rounds of 2.75-in. folding fin aircraft rockets (FFAR) is being held up by a dearth of production sources for the fin-and-nozzle assembly.

A second limiting factor is fuze production, particularly for helicopter use.

The Vietnam conflict is such that stockpiled warheads are something less than optimum, since they were primarily designed for another kind of war—pounding armor and well-dug-in positions or against other aircraft. Newly improved fuzes went into production only last summer and are nowhere near the levels needed to support the 800,000-per-month figure called for by Secretary of Defense Robert S. McNamara earlier this year, nor will present production satisfy current usage of 400,000 rockets per month.

The Navy, responsible for the inert and active parts of all the FFAR motors, is scouring the U.S. for firms to join the few now under contract to fabricate the fin-and-nozzle assemblies. The Army similarly is now attempting to increase fuze production by bringing in new contractors.

DOD officials hope to reach the 800,000 mark by February or March, 1967, almost a year after Secretary McNamara's statement defining the required production rate. Fully assembled units are now only at the 90,000 to 100,000 per month level, flowing from the tri-service arsenal/industrial complex in the U.S. and Canada (M/R, Nov. 22, p. 22).

Army controls program—Faced with almost unbelievable usage rates—which elevates the 2.75-in. rocket procurement level to that of .30-cal. ammunition of past conflicts—a complex, but convenient management organization was thrown together under the executive administration of the Dept. of the Army.

Production control is vested in a Munitions Command project office physically located at Picatinny Arsenal in Dover, N.J. From this office a production complex was designed to feed the FFAR requirements of all three services and is currently struggling to meet the present high production level sought by DOD.

The inherent problem, Army officials say, is to find contractors and qualify them on the aft metal parts of the 2.75-in. rocket's motor.

The Navy is attempting to make a quantum jump in current production of these inert parts to reach a 650,000 to 700,000-unit-per-month level optimistically scheduled for December by DOD. Propellant grain manufacture is substantially ahead of all other components. The motor tube is close behind.

The 800,000-unit requirement takes into account supplying the using services in Vietnam, restoring the inventory now being so savagely depleted and providing training rounds.

A foreign procurement is under discussion with Forges Zebrugge in Belgium. The output of this firm is measured in thousands per year. An R&D effort to come up with a single-nozzle configuration with rotating fins is under way at Italy's Bombrini Parodi Delfino, but this will not have an effect on the current production effort.

The 2.75 rocket, originally designed as an air-to-air weapon, was adapted for air-to-ground use with slower vehicles by scarfing each of the four nozzles. The single-nozzle, rotating-fin approach would more closely fit the basic weapon to the helicopter.

FFAR an antique—The FFAR was also later fitted with a family of heads to meet a variety of needs. For air-to-air use, a point detonating fuze (Mk 176) was used incorporating sufficient delay after impact to penetrate the target before exploding the head. A similar fuze, Mk 178, detonated on impact and was intended primarily for air-to-ground use. Both fuzes were designed for use with the Mk 1 explosive ogival steel head.

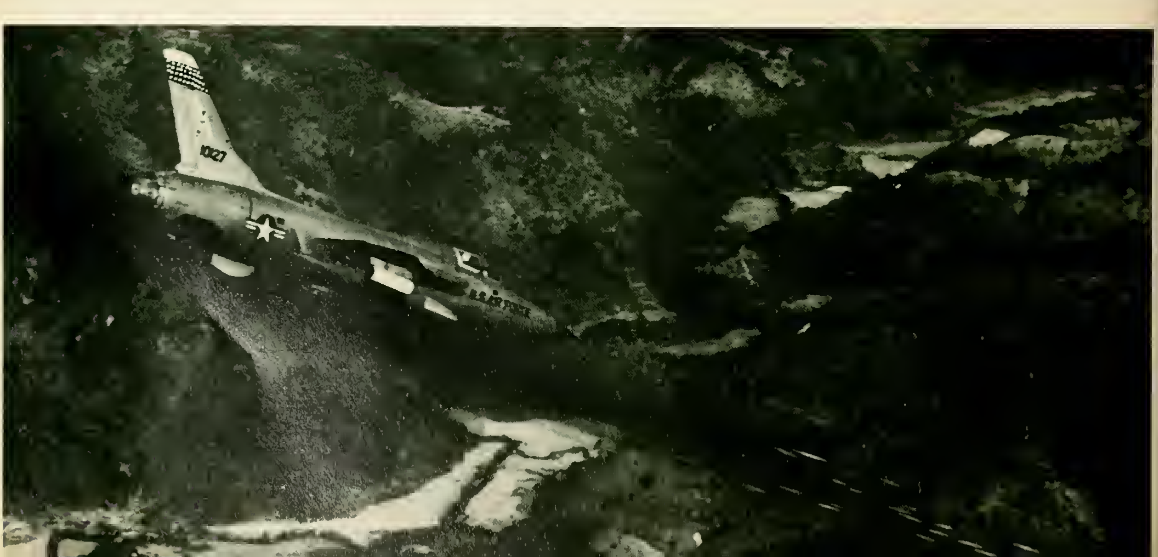
The Mk 5 HEAT (high explosive anti-tank) followed, using the Mk 181 fuze. Two other heads followed, the Mk 3 and Mk 4, which were slug-type armor-piercing. The latter employed a windscreen.

Three motor types were developed for operational flexibility, including one employing a flash suppressor. Loaded motors—without the head assembly—are nonpropulsive and can be stored for relatively long periods.

Weighing some 18 lbs., these were the rounds stored between the Korean war and the Vietnamese conflict. During that time, but particularly during the early 1950's, improvements were made in the propellant but the FFAR remained a fairly conventional weapon for conventional use. The mechanical fuzes were based on a Navy design dating back to the late 1930's.

Improved fuze—With the Vietnam effort came a new need for the 2.75-in. rocket—its air-to-ground application against personnel from both aircraft and helicopter platforms. With this need came the development of a new fragmentation head and development of improved fuzes to better apply the destructive qualities of the advanced head.

First fuzes, the M423 for helicopter



use and the M427 for aircraft use, were built by Bulova Watch Co., beginning in 1964. Essentially the same, only the arming time differs to allow for the differences in speed between the two types of launch platforms. Arming times are 0.6-0.8 sec. from time of rocket motor ignition.

Both fuze designs permit detonation of the head with target impact at any angle to 45° with the surface. (Previous fuzes required nearly perpendicular impact for assured detonation.)

Sudden activation—The 2.75-in. FFAR was completely out of production until March, 1965—when the Army promulgated a requirement for one million rounds. A quick review of the former contractors involved showed that the production lines, raw products and machining equipment had long since been shifted to other uses and the modifications involved wiped out any chance of a fast response to the request.

In addition, the 2.75 extruded grain was wrapped with ethyl cellulose film as an inhibitor. This product was all but out of production.

The Naval Propellant Plant, initially the only facility able to handle the propellant system, set to work to re-qualify vendors and search for new sources. There was no time to develop another inhibitor.

Today, even though the 2.75 is still in the low hundred-thousand-unit per month production level, 40-50% of the world's supply of ethyl cellulose is being absorbed by the program. The only producers—Hercules Powder and Dow Chemical—have geared up, met inspection and quality requirements and are turning out the flake raw product needed to form the inhibitor. These two firms will have to expand production further to meet the 800,000 monthly volume announced by the Secretary of Defense.

The swift increase in demand for this weapon has resulted in re-opening of the Sunflower and Badger Army Ammunition works, increased demands on the Radford Army Ammunition facility and a search for another assembly complex to supplement the Navy's McAlester, Okla., ammunition depot.

The facilities now in the running for the second assembly area include International Telephone and Telegraph Corp., Baldwin Electric, Aerojet-General Corp., Rocketdyne Div. of North American Aviation, Thiokol Chemical Corp.'s Longhorn Ordnance Works, and Louisiana and Lone Star Army ammunition facilities. A choice by the Dept. of the Army is imminent.

Contracts for fin-and-nozzle assemblies have been let to Marquardt Corp., Ogden, Utah; Farmers Tool & Supply Corp., Denver, Colo.; Columbus Milpar Mfg. Co., Columbus, Ohio; American Electric, Inc., Paramount, Calif.; Hoffman Electronics, El Monte, Calif.; Applied Science Inc., Alexandria, Va.; Muncie Gear, Muncie, Ind.; and RMF, Inc., King of Prussia, Pa.

Some of these produce all parts and others are supplied with fins on a Government-furnished basis.

The motor tubes are now being made by Norris Thermador and Reynolds Aluminum. Launchers are procured from Chromecraft—a long-time producer and developer of these parts.

Norris Thermador produces 2.75 motor tubes using a proprietary process that provides for single-piece tube fabrication. This process is licensed. The firm is also one of the major producers of 750-lb. bomb casings.

Present fuze procurement—Six firms are under contract to Picatinny Arsenal for production of the M423 and M427 fuzes: Avco Ordnance Div., Richmond, Ind.; Bulova Watch Co., Jackson Heights, N.Y.; Gibbs Mfg. and Research Corp., Janesville, Wis.; Hamilton Watch Co., Lancaster, Pa.; KDI Corp., Cincinnati, Ohio; and Westclox Div. of General Time Corp., Stanford, Conn. Production contracts were awarded in June, 1965.

OPPOSITE PAGE: 2.75-in. rockets pour from pod of F-105 during strike against Viet Cong. The weapon's fragmentation head has made it an extremely effective anti-personnel weapon. LEFT: Propellant for the rocket is received in this "carpet-roll" form. The grain is extruded to proper dimension, cut, wrapped with cellulose, and shipped to motor assembly plants.

Seeking to broaden the present industrial base, Picatinny solicited bids for return on April 1 for additional production of the M423 fuze. Three to six new contractors will be selected. Facility inspections of those selected are expected to begin this week.

Production build-up for fuzes reportedly has been slow. Potential manufacturers have exhibited a reticence to build and staff production lines without firm contracts in hand.

Best fuze output to date, informants claim, is still well under 250,000 per month, with production varying among contractors from 16,000-50,000 per month. Gibbs workers are now on strike, but the strike may end soon.

Army officials reportedly are pressing contractors for a production increase to at least 100,000 each per month and then to 150,000 within the year. Industry informants indicate such a goal is highly optimistic. However, since the ultimate production program calling for at least 800,000 units per month will require expenditures approaching $400 million a year, the lure of the dollar may serve as an effective incentive to both present and new fuze contractors.

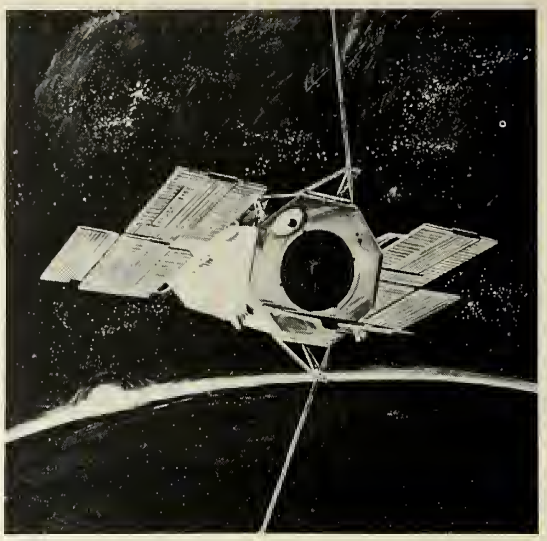
The bulk of the M423 and M427 fuze components require machining; thus there is a limit to the minimum time needed to turn out parts. Additional machine tools and trained personnel must be obtained to further accelerate production, manufacturers say. Firms are hesitant to invest heavily in such a program since there is no assurance of long-term production needs. The reluctance of the Johnson Administration to declare a formal U.S. mobilization tends to make priorities ineffective as a prod to increase vendor assistance in both material and parts, informants say.

R&D continues—In addition to broadening its production of the mechanical fuzes so urgently needed, DOD is also applying technological advances for 2.75-in. rocket improvement and also thus creating new potential producers.

On April 4, Harry Diamond Laboratories, fuze developers for the Army, received bids for a seven-month project for engineering and development leading toward a new velocity-time fuze for the FFAR. To be designed for velocity-time arming, the proximity fuze is expected to be employed with the anti-personnel fragmentation head.

Two firms will be selected to pursue the development. (Firms represented at the HDL bidders conference in March included RCA, Sperry, Honeywell, Avco and Zenith.) ■

this 22,000 part stabilization system



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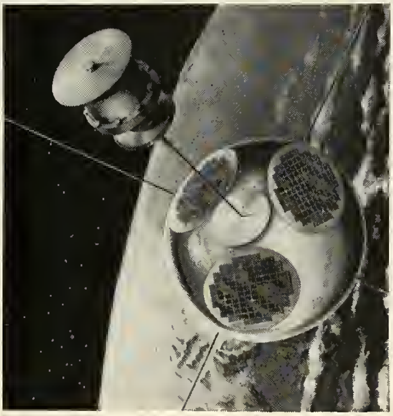

will have a lot hanging in the balance.

OAO and MAGS for example... with Nimbus, GGTS, and ATS somewhere in between. Which may give you some idea of how flexible our approach to space engineering is. To achieve the exceedingly accurate pointing requirements of the Orbiting Astronomical Observatory, we came up with a 22,000 part active control system which uses tiny rockets, gas jets, and thousands of electronic and mechanical parts to position the spacecraft and keep it there within one-tenth of a second of arc. Our Gravity Gradient Stabilization System, on the other hand, is a passive system with few moving parts and uses no power for operation, utilizing the earth's natural gravitational field to make a satellite constantly point to the earth to within two degrees of arc.

Our spacemanship is equally dexterous in other areas. SNAP-27 will be the first nuclear power system for operation on the surface of the moon. SPET (Solid Propellant Electric Thruster), with no valves, no moving parts, promises to be extremely valuable for increasing the reliability of active attitude control systems. In the important area of manned vehicles, we're working as a prime contractor on MOL. And we're studying a Voyager to go to Mars. Beyond that, we have ideas that haven't even reached the drawing boards yet.

If you have ideas on the subject, look into these opportunities: nuclear power, nuclear chemistry, thermionics, environmental control, IR/optics, simulation, human factors, life support, structures and weights, reliability, guidance & control, measurements and environments, materials development, spacecraft design.

Write in confidence to Mr. J. S. Barson, Dept. 394D-3, Valley Forge Space Technology Center, General Electric Co., P.O. Box 8555, Philadelphia, Pa.

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Technical Countdown

MATERIALS

Avco Working on Pacemaker Program

Ablative heat shield material similar to that designed for the *Apollo* system will be installed on two flight-model *Pacemaker* spacecraft by Avco's Space Systems Div. The units will make suborbital flights to get data on heating rates caused by protrusions above a spacecraft's surface. Umbilical cover, shear pad and maintenance door gaskets will be simulated on the flight-test models. The $182,166 contract with NASA's Langley Research Center also calls for one protoype spacecraft besides the flight hardware.

PROPULSION

SPARM Flies Aboard Drone

A solid-propellant augmented rocket motor (SPARM) mounted in a modified *AQM/37A* target drone was successfully launched recently from an F4B aircraft at the U.S. Naval Missile Test Center, Point Mugu, Calif. Developed by the Huntsville Div. of Thiokol Chemical Corp. and funded by the Air Force Directorate of Armament Development, the SPARM system includes an integral booster to accelerate the vehicle to cruise velocity. A ducted rocket afterburner section houses the ejectable booster. Thiokol experts say laboratory testing conducted in the mid-1950's demonstrated the feasibility of achieving specific impulse of 500 lb.-sec. per lb.—and they claim this figure can be substantially increased in the immediate future.

High-Pressure Engine Facility Built

Rocketdyne's Liquid Rocket Div. is operating a new high-pressure test facility designed to handle rocket engines developing up to 500,000 lbs. of thrust with chamber pressures of 3,000 psi. Constructed with company funds, the facility paves the way for the next generation of engine technology. Current engines operate in the 1,000 psi or less range and the next step in powerplant technology is the use of higher internal pressures coupled to advances in nozzle design. Located at Rocketdyne's Nevada Field Test Lab near Reno, the complex is also equipped with a diffuser allowing engine runs at simulated altitudes of 60,000 ft.

Porous Injector 'Infinitely' Reliable

A "controlled-pore concept" developed at Vacco Valve Co. and applied to the injection of liquid propellants into a combustion chamber is said to be reliable "to the point of infinity." The concept is a natural outgrowth of the firm's multi-segment filter and is still under test. No details as to other performance factors were released.

ELECTRONICS

Solar-Pumped Laser Tested Successfully

One watt of continuous laser output power has been achieved with a solar-energy-pumped neodymium-doped laser crystal by American Optical Co. Under an R&D effort sponsored by the Air Force Avionics Lab at Wright-Patterson AFB, the experimental system was developed to collect energy from a modified Cassegrain Sun-tracking telescope and feed the energy to a water-cooled laser rod. According to AO, a spike-free output sufficient to employ for space communications was obtained for up to several hours at a time throughout the periods of test. Researchers believe that higher outputs can be achieved if such a system is tested beyond the atmosphere.

Transistor Failures Predicted by NBS

A three-year study by the National Bureau of Standards of germanium-alloy transistors has produced a method for predicting potential failures in such units prior to actual service in circuits. Essentially, predictions are based on measurements of transistor leakage currents. NBS researchers found that early increases in leakage currents among test samples were consistently associated with early transistor failures during later, accelerated life tests. The technique also indicates which junction will deteriorate more rapidly.

SPACE MEDICINE

AF Completes 70-Day Inactivity Study

The Air Force has concluded a 70-day experiment on the effects of inactivity using five volunteer subjects with age, training and experience qualifications similar to those of astronauts. The men were confined to complete bedrest for six weeks, during which blood tests were taken daily to study blood cell formation and rate of red-cell destruction under inactivity conditions. Calcium studies also were conducted. Results are now being analyzed.

Animals Survive 236 Days in 100% Oxygen

Experiments at the Aerospace Medical Research Laboratories' Toxic Hazards Division indicate that survival under long-term exposure to a pure oxygen atmosphere at reduced pressure of 5 psi is indeed possible. More than 100 animals —including mice, rats, dogs and monkeys—spent 236 days in an altitude chamber and showed normal results from blood-count and chemistry tests. Although 11 rodents died during the time, the survival rate was better than in the control group, and was not considered unusual in long-term experiments with such animals.

AF Reports on Confinement Tests

The Air Force's Aerospace Medical Research Laboratories reports that there seem to be no problems with prolonged periods of restricted human physical activity, provided sufficient exercise is available to maintain metabolic efficiency. In a recent series of tests, three groups of four men each were confined for 28 consecutive days, exercising regularly on a bicycle ergometer. In general, the prolonged confinement caused no significant measurable physiological changes from control values recorded before the test, the Air Force asserted.

SAM Produces Space Dental Kit

A dental repair kit for astronaut use is being tested by the Air Force School of Aerospace Medicine in a 12-day simulation chamber training test. Developed under the direction of SAM's Dr. James Hartley, the 1.3-lb. kit is being proposed for possible use in orbital spaceflights of long duration. Dental troubles such as a gum infection, trench mouth and a filling break delayed three chamber simulations at SAM, provoking the research. The kit includes forceps to pull teeth, local anesthetic and filling material to permit one astronaut to perform emergency dental work upon the other.

UTC Chief Sees Tighter Rocket Market

by Robert Lindsey

Sunnyvale, Calif.—U.S. rocket propulsion firms face mergers or possible extinction because of over-capacity and a prospective lack of new programs.

Barnet R. Adelman, president of United Technology Center, division of United Aircraft Corp., made this prediction on the firm's fifth anniversary.

Adelman says the industry has probably hit bottom in its current recession, but that when it starts to climb again, excess capacity will continue and some realignment is "very likely." Quality performance will determine which firms survive, he says.

Other points made by Adelman include: an implication that something is about to break—or already has—on UTC's long wait for a 120-in. motor production contract, a prediction that tactical weapons should help boost the industry out of its current doldrums, and the observation that hybrid rocket technology is advancing so fast it seems certain to leap-frog very-large solid motor technology.

"I don't expect that there will be any real use for 260-in. motors, at least in the foreseeable future," he says. UTC is continuing to diversify wherc it sees opportunities, including production of napalm, proprietary life-support systems and commercial glass fiber structures.

Rounding the corner—Commenting on the general health of the industry, Adelman says: "I think the rocket business right at this moment is at the bottom of the depression. I think we are starting to come out of it.

"Nevertheless, there is over-capacity in the industry and, for various reasons, many people in the industry have built facilities too late.

"Sooner or later, the Government is going to have to make up its mind that those that produce successfully for it will be the ones that continue. The result—I do not know what will happen to them, whether there will be mergers or some will go the way of the Reo."

The future isn't as dim as it may seem for the industry as a whole, Adelman said. "I think there'll be a substantial amount of business in the tactical area, and sooner or later there will be a new ICBM, and it will be either solid or a hybrid."

Stress on hybrids—Hybrids, says Adelman, will be the next major area of propulsion development. He disclosed that UTC, perhaps the industry leader in hybrids, is negotiating a contract with the Air Force to build and test-fire a 200,000-lb.-thrust hybrid motor, by far the largest built so far. UTC, which has been working on hybrids with company funds and contracts from NASA, the Navy and Air Force since 1961, has brought the technology along to development of such an engine.

"The advantages of hybrids are very clear for tactical and large boosters, and hybrids may very well be the major advance in chemical propulsion systems in this time period.

"Right now hybrids are getting to the stage at which they are being considered for operation use. If technology is the governing factor . . . and there are other factors, such as political ones—I would say that if there are rockets developed in the 260-in. class, they very likely should be hybrids," Adelman said. Tactical weapons of the mid-1970's, he said, should rely heavily on hybrid designs.

Deep in 120—Despite UTC's efforts to broaden its base of business, its future seems tied inextricably to the 120-in. program.

More than 75% of its total business since the firm was organized has come from this source. Although Adelman declines to go into details, it appears the company will get at least a major share of the expected large volume of 120-in. motor procurement. However, other propulsion companies have intensified demands for part of the business. Adelman emphasizes his company's position on the morality of the issue.

Noting that UTC had invested many millions of dollars of UAC funds to develop the 120-in. motor, he said, "If an outfit does a job successfully, it should get the continued development and production contracts to make such a risk worthwhile. If the policies of the Government become such that this situation does not prevail—if an outfit takes a risk and is successful and does not get the necessary production work to make a profit—it's real clear there won't be very many outfits taking such a risk. No one in his right mind will take a risk of such magnitude to get a single development contract."

Genesis—UTC originally was formed in mid-1958 by a small group of engineers and scientists, led by Lt. Gen. Donald L. Putt, former chief of the Air Force's Air Research and Development Command, to do research in rocket propulsion. This was reflected in the group's original name, United Research Corp. Most of the founding group had played important roles in the Air Force ballistic missile program and the pooling of their talents represented a considerable concentration of the nation's capabilities in rocket propulsion.

"It was planned to do research until a significant breakthrough occurred," Adelman recalled. "After we thought about that for a fairly short time it became clear we had to set up a complete research and development organization if we were to compete in the industry." This led to a commitment by UAC of over $30 million, a massive calculated risk, in company-funded research and development and facilities, to establish itself in the industry.

"We had two self-imposed restrictions," Adelman said. "We would not build turbo-pump systems; Pratt & Whitney was already established in this field. In the liquid area, we would confine our responsibility to storable and pressure-fed systems. Secondly, we would not pursue nuclear engines for the foreseeable future. Based on the experience of some of us and observations on what appeared to be the path of both space and the ballistic missile program, it seemed large solid-rocket propellants would be the major area of advancement and utilization in the next decade or two."

UTC claims credit for developing the segmentation concept for large motors during this period and also for defining 120-in. as the optimum, easily transportable diameter for large motors, and 156-in. as the maximum size that could be transported over the nation's railways. Originally, UTC favored conical segmented rockets, permitting use of any number of tapered segments to build rockets of varying thrust.

As UTC—together with other firms—pushed company-funded work on large solids. NASA and the Air Force became interested and began funding. In 1961, UTC fired the first large segmented motor. The next year, UTC won the hard-fought program to develop the *Titan III-C* solid motors.

Solid proof—The past five years, Adelman observed, have clearly established what a few lonely evangelists for solid motors were arguing for at the beginning of the decade—that large solid boosters can compete with liquid systems in most missions and beat them in many.

He credits development of successful fluid-injection thrust-vector-control systems, efficient propellant formulations and the segmentation concept, among other things, for turning the corner for large solids.

One critical breakthrough which has not been widely recognized was development of nozzle designs and grain configurations which made it possible to extend the burning time of large solid motors to the present level of about 120 seconds.

Asked about his philosophy of management, Adelman, who took over as UTC president four years ago after Putt was promoted to a vice president of UAC, summed it up this way: "First, it is to get the best people you can possibly get. Second, you provide them with the best tools you can get and let them do the work with one thing foremost: that there is absolutely no compromise in quality. You do not permit any other consideration to take precedence—not schedule, not cost, not anything. In the end, the products we deliver must be reliable.

"You lose business this way. We have lost competitions simply because we refused and will continue to refuse to say we can do things we can't. You have to have quality in this business. Our prices reflect this; they may be higher than others', but these products which large systems depend on must be the most reliable things ever produced."

The perennial question around UTC for months has been: what's happened to the 120-in. contract for the *Titan III-M*—the seven-segment design to boost the *Manned Orbiting Laboratory*—and the *Titan III-D,* utilizing two-, three- or five-segment strap-ons.

On this point, Adelman was painstakingly cautious. He implied that the company had received good news on the question, but refused to specify because both are "highly classified" programs. But he did say this:

"We look forward to a substantial program with the 120-in. motors. There is a good indication that a substantial number of payloads using 120-in. motors with a various number of segments are being planned. (See page 14.) We look forward by the end of this year to a substantial increase in the utilization of these rockets. There is every reason to believe uses for 120's are on the way up." ■

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systems analysis

Aerospace Firms Getting Call To Evaluate Chinese Threat

by Rex Pay

Santa Barbara, Calif.—Increased aid from the aerospace industry in evaluation of Chinese Communist technology is being sought by U.S. intelligence agencies as a means of anticipating the pace of Chinese missile development.

Hitherto, much of the analysis of Chinese technological advancement has been in the hands of economists, working on open literature, or military intelligence working with material from secret sources, including surveillance overflights by aircraft or satellites.

However, study of open literature by scientists or engineers can be extremely revealing, as was shown by the successful prediction of the first Chinese nuclear explosion by nuclear physicist Jack Berberet of General Electric Tempo.

Familiarity with the problems of producing fission weapons and an assessment of Chinese capabilities enabled Berberet to predict, over two years ago, a uranium 235 bomb, using the implosion technique. In contrast, Britain, the Soviet Union and France exploded plutonium weapons first.

Berberet's predictions were based on resource analysis, which involved examination of the availability of such items as qualified personnel, raw materials, production processes and engineering capability.

The analysis, which appears in a Tempo report, "Science and Technology in Communist China," was financed in-house. Although the State Dept., Central Intelligence Agency, Defense Intelligence Agency and others were aware of this work, nearly three years passed before such agencies began issuing requests for similar studies.

Impetus for this is a growing realization that China may be able to develop a missile capability fairly easily. Furthermore, it is apparent that missile systems engineers are capable of foreseeing problems the Chinese will meet and forecasting how quickly these can be overcome. For this reason, these engineers can provide a valuable input to the intelligence gathered through clandestine sources.

Computers—One of the chief requirements for an understanding of Chinese problems in missile development is an assessment of Chinese computer technology. Trajectory and flight dynamics programs are readily available in the western world; the Chinese require only the computers and the ability to use them to be able to design missiles.

Materials and production problems may mean that the missile will not be optimized to the degree that western engineers seek, but this will by no means diminish the political significance of a Chinese missile.

The Chinese have a missile range in Northeast Sinkiang. The climate there is comparable to North Dakota, but this is probably the best Chinese land area available for missile testing. Missile facilities were originally brought there by the Soviet Union.

Electronics—Closely following computer technology in importance to missile development is electronic technology, including circuit and component design.

Chinese electronics development has reached the stage of production of solid-state devices. These are being used in transistor radios and for development of solid-state computers. Transistor radios were produced early in the program since communications are extremely important to the Chinese for indoctrination and for coordination of activity.

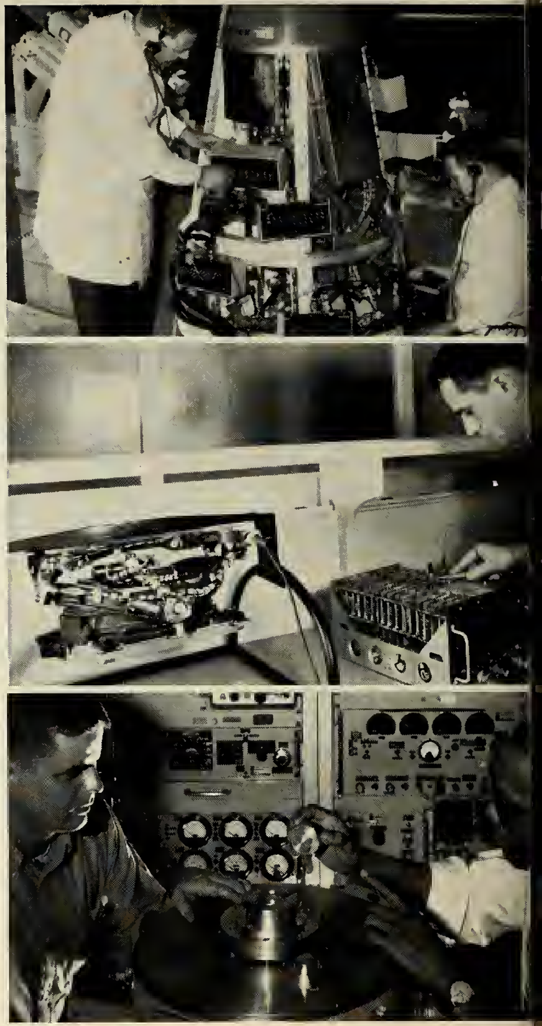
U.S. intelligence also lacks sufficient information on such aspects of Chinese technology as applied chemistry, applied physics, metallurgy and meteorological research.

Investigation of Chinese developments in these areas provides information beyond that needed specifically for assessment of missile threats. Other broad areas requiring study include analysis of scientific and technological goals in China, postgraduate training in science and technology, and patterns of scientific and technological publications.

As intelligence probing becomes more specific, studies become more closely associated with classified material. Here, the aerospace industry also has valuable expertise to offer. It can, for example, analyze the topography of China and predict the location of radar sites for detecting overflights of aircraft and missiles.

Human resources—While studies of education may appear to be somewhat irrelevant to missile systems in comparison with studies of radar systems, it is from education that some of the biggest

What you can expect from General Precision.



KEARFOTT STELLAR INERTIAL GUIDANCE SYSTEM (STINGS)—This
precision guidance system for missiles recently completed a succe
series of stellar acquisition feasibility flights (STAFF) for the U.S
Force. It uses the stars to update the inertial guidance system. (Top

GPL MINIATURE DOPPLER RADAR NAVIGATION SYSTEM—For airb
navigation. Provides altitude and flight parameters with highest p
sion. Perfect for all fixed-wing, helicopter and VTOL aircraft. (Middl

KEARFOTT PRECISION COMPONENTS—New gyroscopes under dev
ment promise performance equal to conventional gyros priced 2
times higher. Will be used in low-cost inertial system now being d
oped. (Bottom)

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CONTROL SYSTEMS FOR AIRCRAFT & MISSILES

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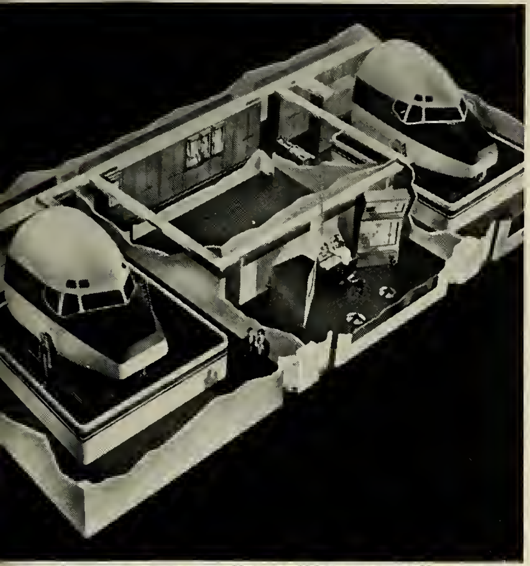

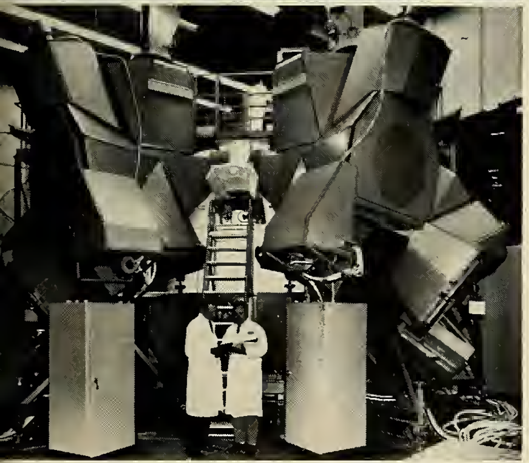

MERCIAL AIRLINE SIMULATORS—The twin cockpits of this 707 jet lator can be driven singly or simultaneously by a Link GP-4 high-city digital computer. One GP-4 can also drive two different air- simulators such as supersonic transport and DC-8-61. (Top)

LLO MISSION SIMULATORS—The primary training systems for moon nauts, they will simulate the entire mission including launch, ren-ous, docking, re-entry and earth landing. (Bottom)

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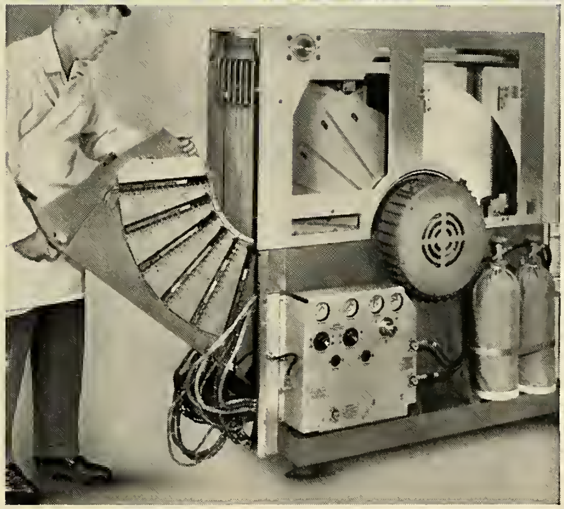

WEAPON CONTROL SYSTEM FOR SUBROC — Librascope manufactures computing and data display system for launching and directing flight path of this advanced anti-submarine missile. (Top)

MASS MEMORY SYSTEM—Can store over 300 million bits of information. Used in large data processing systems such as giant Librascope AN/FYQ-11 in Air Force Command-and-Control Center at the Pentagon. (Bottom)

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surprises could come. If China can educate enough high-caliber scientists and engineers, they can use available Western technology as a departure point for their own developments. Similarly, with such personnel, the recent acquisition of a steel mill and concrete plant provides the basis for development of a nuclear reactor capability. This in turn gives an insight into shielding and radiation problems of a military type.

Resource analysis can, of course, be applied to countries other than China. It could be directed toward Israel or India to gain insight into how soon these countries will develop a nuclear device.

Analysis of the Chinese missile threat starts with an understanding of the Chinese strategic situation and international goals. According to one view, it would be most advantageous for the Chinese to develop a ballistic missile with a range of 700 miles or more. This would be a threat to part or all of Japan, Korea, Taiwan, the Philippines, Vietnam, Malaya, Thailand, Cambodia, Laos, Burma, Pakistan and India.

Subsequent development of a submarine launch capability for a missile of this range would make it a threat to all countries in the Far East because of their general lack of the technological development needed for effective antisubmarine warfare.

Japan, however, is actively developing an ASW capability with considerable encouragement from the U.S. The Japanese are the only foreign nationals being trained to operate the Dash unmanned ASW helicopter at the Navy's facility at San Clemente Island.

It is logical to expect the Chinese to develop a solid-fueled missile since this can be handled on a submarine, and deployed inconspicuously on land, and has a rapid reaction. Early Soviet influence was, however, in the field of liquid rocket development; this may have deflected Chinese progress.

Motivation is key—According to Arthur Kvaas, head of Tempo's Technological Environment Studies, development of a missile by the Chinese is a simpler problem than development of a nuclear weapon. "The technology is available," he pointed out, "so the key question is the motivation." Kvaas believes that the large amount of information published on the design of earlier U.S. and Soviet rockets provides a suitable basis for Chinese missile production.

For guidance systems, the Chinese could make use of German technology available at the end of World War II. They are also improving some relevant technology from Japan and other countries. They may even be content with an unguided rocket if their computer and meteorological technology improves sufficiently.

"The big question is the amount of support the people want to give it," said Berberet. "And you know they are going to give it a fair amount of support . . . I would estimate that they are probably giving a lot of time and effort to rocket development."

Berberet believes the Chinese Government is not worried about population or agricultural problems. They have only a small fraction of the fertilizer they need, he pointed out, but this deficiency could have been overcome if they had re-allocated the money devoted to nuclear weapons development to this end.

Parallel routes—The use of uranium 235 for the first fission weapons exploded by China is interesting, said Berberet, because it indicates a capability of high-precision machining. There is a need for accuracies of 0.0001 in. in the diffusion process used to separate uranium 235 from the more common uranium isotope.

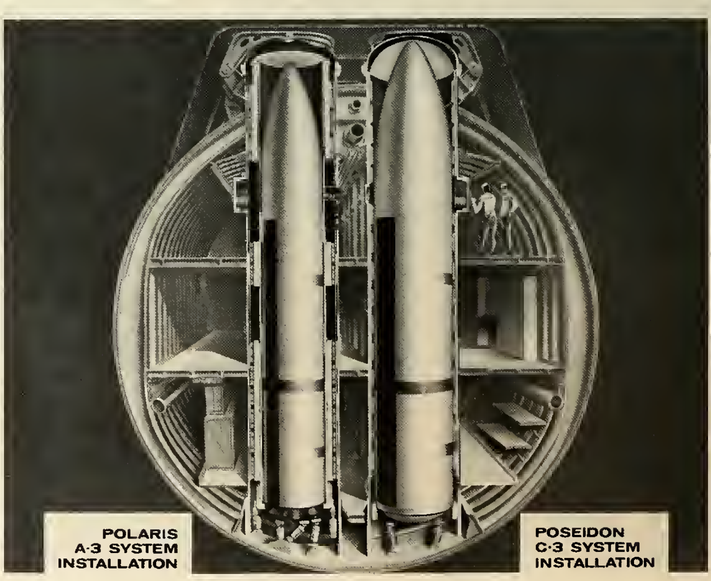
The alternative route of fission weapon production, use of plutoninum, encounters quality control problems. Also, the material is very difficult to handle and raises stringent metallurgical problems, including a very large requirement for stainless steel.

"I would guess probably they have gone parellel routes," said Berberet, "because it is certain that for any sizeable nuclear program they will have to have both materials. However, the difficulties on the uranium 235 route are easier to get around."

Berberet said that the implosion technique used in the Chinese fission device was to be expected since they were probably not trying for a high degree of efficiency. Once such a technique has been shown feasible, its development is easier. Also several books give the main ideas for lens manufacture.

Though it is difficult to pinpoint the exact period required for development of a deliverable weapon, after explosion of a demonstration device, Berberet estimated the time at about one to two years.

Chief relay point for published material from China is the U.S. Embassy in Hong Kong, which monitors all Chinese sources. The amount of information coming out of China has increased considerably since 1964 when China relaxed restrictions on the outflow of technical papers. Increased appearance of astronomy in this material indicates a probable interest in space technology and satellite development in China. ■



Simplicity of Polaris-Poseidon Switch Shown

Comparison shows how larger and more powerful Poseidon ballistic missile can replace Polaris missile in existing Polaris submarines with minor and relatively inexpensive changes. Only the launch tube needs to be replaced as a result of Navy and Westinghouse Electric Corp. systems planning (M/R, Dec. 7, 1964, p. 14). The Westinghouse missile launching and handling department in Sunnyvale, Calif., has received a Navy contract to develop Poseidon launchers (M/R, April 11, p. 28). The steam-eject system used with Polaris A-3 will be able to handle the Poseidon.

LUNAR ORBITER camera-carrying spacecraft is being lowered into 50-foot-high space chamber at Boeing Space Center. During "flight" tests in chamber, NASA's Boeing-built Lunar Orbiter simulates a photographic mission to the moon, involving translunar journey and nine lunar orbits. The Boeing chamber simulates altitude of space and temperature extremes matching those on the dark and sunny sides of moon (minus 300°F. to plus 250°). Boeing Space Center contains ten other space environment chambers, used to test materials, components and vehicles to obtain prelaunch operating data. Solar radiation, deep space temperatures and altitudes up to 600 miles can be simulated.

Capability has many faces at Boeing

NASA's Lunar Orbiter, seen above and in picture at top, will be launched this year to photograph large areas of moon surface to help select best landing spot for American astronauts.

HiBEX, high-acceleration missile booster, shown being test fired at White Sands Missile Range. Tests, sponsored by Advanced Research Projects Agency with Boeing as prime contractor, are part of a study of ballistic missile defense systems.

NEWEST jetliner, Boeing 737, will carry up to 117 passengers at 580 mph, and will offer more head and shoulder room than any other short-range jet. Already ordered by Braathens, Irish, Lufthansa, Mexicana, Northern Consolidated, Pacific, Piedmont, United, Western and Wien Air Alaska.

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Image of farm buildings taken by dielectric tape camera, transmitted electronically, then displayed and processed as a conventional picture.

Dielectric Camera Ready for Space Use

by William S. Beller

PRINCETON, N. J.—A novel camera embodying reusable "film," electronic processing, extremely high radiation resistance, and high-density information storage is now ready for space work.

The camera, developed by Radio Corp. of America's Astro-Electronics Div., uses dielectric tape for recording and storing images. After readout, the tape can be erased and used again.

Early work on the camera system was sponsored entirely by RCA, but in 1959 the Air Force contracted with the company to develop components for a high-resolution, frame-type dielectric tape camera. A year later, RCA began work on a meteorological panoramic camera using dielectric tape for NASA.

Subsequently, the .company began developing and space-qualifying the NASA system to *Nimbus* satellite test levels. This job was recently completed.

RCA is now proposing that the system be used not only for meteorological purposes but also for lunar mapping, Mars mapping and for the entire class of missions "requiring repetitive visual imaging and high-capacity data storage." It could give image resolutions approaching photographic systems used with electronic readout, RCA said.

Types of camera systems—A photographic system for space operations uses a film camera as the sensor and storage device, and subsequently a film processor, flying-spot scanner and scanner electronics to develop the film and put it into form for transmission to Earth stations. The obvious advantage of this system is the ability to get high resolution of the target. A disadvantage is the limited number of exposures it can take and in the film's vulnerability to radiations such as those from solar flares or the Van Allen belts.

Another camera system is the electronic imaging system, which has been used in a number of space applications, including *Tiros*. Here, the image sensor is a vidicon camera and the storage medium is a magnetic tape. The magnetic tape output is an electrical signal easily matched to the spacecraft communications system. This camera system is said to need higher power and appreciably more weight to do the same job as the dielectric tape camera.

In discussing use of the dielectric tape camera system for "high-quality photographs of the Earth's cloud cover," Joseph Arlauskas, Goddard Space Flight Center engineer concerned with meteorological camera work, noted the camera resolution of 600 television lines per inch at 50% response. This compares favorably with that obtained from typical vidicon cameras.

More significantly, however, "the large increase in sensor area provides a ground resolution of 0.2 nautical mile, which represents a significant improvement in resolution for the available ground cover," he said. The Goddard engineer also noted that to obtain a comparable level of performance with more conventional vidicon magnetic-recorder systems, "a minimum of six cameras would be required with attendant power and a weight significantly higher than that required for the (dielectric) tape camera system."

In the dielectric tape camera, "the image sensor and storage medium are both in the camera head," John Dilley, RCA's manager of tape cameras, told MISSILES AND ROCKETS. Upon command, the stored information is read out as an electrical signal and is immediately suitable for transmission over a communications system.

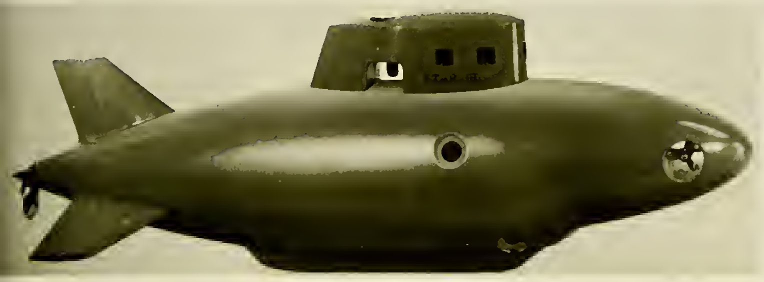
Dielectric tape system—A typical meteorological dielectric tape camera system would use about 100 ft. of 35-mm tape. In design, the tape is made up of a flexible base of cronar tape coated essentially with a thin photoconducting layer and, on top of this, an insulating layer. The optical image is "written" into the insulator and stored there until read out or erased.

When the system is operating, the tape unwinds from a storage reel and is first hit by a flood of electrons to erase past images and establish a uniform known potential. The target is then imaged optically on the tape, which is electron-flooded at the same time to create a charge pattern on the insulator proportional to the amount of illumination falling on the tape. For the camera developed for the NASA system, the target image would be gathered by a scanning mirror arranged to scan at right angles to the flight path to get horizon-to-horizon pictures of Earth.

The image would then be read out or stored on the tape as it moves onto a windup reel. For readout, a finely focused, high-velocity electron beam would measure the differing potential on the dielectric tape.

Zoomability—Because of the nondestructive readout ability of the dielectric tape camera, the device can "zoom in" on a target of high interest. Remarking on this point, Edwin Walthall, RCA systems engineer, noted that the camera can be used in a dual mode, first scanning the tape with a fast scan for a coarse-resolution readout of the entire tape storage. This then permits a selection of the interesting areas of the tape to be scanned and studied at high resolution, all within the same bandwidth. Moreover, the entire process can be done by commanding a minor change in the electronics, resulting in a slower scan rate readout for the higher resolution. ■

Developers Outline Undersea Research Vehicle Expectations



Model of Star III, undersea research vehicle built by General Dynamics' Electric Boat Div., designed for depths of 2,000 ft. Vessel is scheduled to be launched May 3.

by Robert W. Niblock

WASHINGTON—Major industrial concerns building undersea research vehicles (URV's) express the unanimous conviction that a market exists for their products—but the majority talk in terms of long-range amortization of these investments.

Although exuding confidence and enthusiasm, most industry spokesmen readily admit that it is difficult now to say precisely when the payoff on URV's will come and how much it will be. As put by William L. Sparks, marketing manager for the Westinghouse Underseas Div., "There is a market now for URV's, but a very limited one. Anyone going into the submersible business better figure on the long, long haul."

General Dynamics' Electric Boat Div., Groton, Conn., which plans to launch two new URV's on May 3, sees, on the other hand, a "tremendous potential" right now for their use, primarily on a lease basis. Apparently a variety of organizations have expressed interest in using the new Electric Boat vehicles, Star II and Star III. However, most agree that their investments will not be retrieved overnight.

Lockheed Missile & Space Co., which will receive the Navy contract to build the prototype deep-submergence rescue vehicle (DSRV), is very optimistic about the URV market and says that it "probably could, if it wished, lease its Deep Quest 100% of the time." Deep Quest is still under construction and the company has plans for using the vehicle itself part of the time to gain experience with a working oceanographic tool. Lockheed, like many other companies in the URV business, expresses faith in a market which it has not yet been able to "clearly define."

Opening wedge—For some firms, the URV offers the best door into the undersea field. The Thresher disaster showed at least one obvious need for manned submersibles. In these exotic URV's, the builders have a method for clearly establishing an image in ocean engineering and research. The company-owned vehicles also provide a potent research tool for in-house oceanography projects.

Major markets for the URV's now or soon-to-be operational are in the military and scientific communities. For example, Westinghouse's Deepstar 4000, still undergoing Navy safety certification, will first be leased by the Navy Electronics Laboratory at San Diego, Calif. Westinghouse also leased the diving saucer to the Scripps Institution of Oceanography for underwater geology studies. Electric Boat leased Ashera to the University of Rhode Island and to the Bureau of Commercial Fisheries while it was not in service by the University of Pennsylvania, for which it was built. The Navy contracted with Ocean Systems, Inc., for use of the Perry Cubmarine PC3B—a URV which has also seen service under industry contracts.

The lost H-bomb in the waters off Palomares, Spain, has, like the Thresher incident, substantiated both the need for and value of URV's. Also, the incident demonstrated again the wholly unexpected events which can influence the ocean business. With its Navy charter on the bomb operation, Reynolds International received its first major return on the outlay for the Aluminaut. The Perry Cubmarine also was used at the Spanish search scene under another Navy contract.

Reynolds spokesman Charles Sanders, assistant to company president J. Louis Reynolds, says that the concern "definitely believes" it can make money from the Aluminaut. He said the company is planning to build another URV but no details are available on its design or the starting date for construction. Sanders lists government agencies, universities, oceanographic research institutions and treasure-hunting and salvage groups as potential markets for the URV.

Vehicle indicators—The types of URV's organizations have built or plan to build indicate various approaches to the marketing situation.

Westinghouse, which began its URV work a year before the Thresher disaster, believes in the "small, simple, air-transportable" kind of submersible. Its approach is to make a relatively small investment in the URV and keep the design small and simple so that logistic support costs do not become a burden. This approach, Westinghouse believes, will keep the company competitive in the market.

Both Westinghouse and Electric Boat subscribe to the "family of vehicles" concept—that is, to build a number of small vehicles for specific tasks rather than one large multipurpose URV. The Westinghouse Deeptsar family will consist of the now-completed 4000, the 2000, which is under construction, the 12,000 and the 20,000. These number designations indicate the depth capabilities of each URV. Electric Boat's Star II, which is an improved sister ship of the Ashera, will operate at 1,200 ft. The Star III will be a 2,000-ft. URV and will have a manipulator which a company spokesman said could perform all the functions of the human hand and arm.

Lockheed's entry in the URV field, Deep Quest, is a big deep submersible that will have a broad range of capabilities.

The pressure hull for Deep Quest was completed at Sun Shipbuilding, Chester, Pa., several days ago and the company hopes to have the vehicle ready for its first tests this fall. The conceptual design includes a lock-in/lock-out capability for divers.

All companies say they are prepared to offer, on a lease basis, both their URV's and all the supporting personnel and equipment required. The relative ability of each to provide a complete URV system may well determine its ability to compete successfully in this developing market. It is, of course, essential to have a reliable URV, but unless the vehicle can be supported efficiently and effectively in a broad variety of operations, it is of little value to potential users. ■

Voyager Impact Pegged at 2,000 G's

Los Angeles, Calif.—A touchdown shock at the Martian surface of about 2,000 g's is currently being assumed in *Voyager* lander studies at Jet Propulsion Laboratory as a result of reassessment of probable atmospheric and surface characteristics of the planet.

This has given increased impetus to the JPL high-impact survival program for development of mechanical and electronic equipment capable of surviving 10,000 g's impact.

One lander capsule designed to survive the impact on Mars is a 22-in.-dia. balsa-wood sphere coated with glass fiber. Total weight of the landing capsule would be 185 lbs. It would be falling at a vertical velocity of about 100 fps as it approached the Martian surface.

The high impact forces anticipated come from a JPL model of the Martian surface, derived from radar and optical astronomy, and from *Mariner IV* television data. Further refinement of the model is likely when the principal experimenters for the *Mariner IV* television system present a final report.

Mariner IV data—Speaking at a recent American Institute of Aeronautics and Astronautics meeting here on advanced unmanned interplanetary probes, Dwain F. Spencer of JPL said that the 0.5% sample of the Martian landscape scanned by *Mariner IV* showed variations in properties between dark and bright areas. Slopes in the bright areas, considered to be low-elevation sand dunes, varied from zero to 45 degrees, said Spencer. In the dark areas, the slopes were generally between zero and 30 degrees, but vertical slopes were also present. The dark areas appear to be mostly of low elevation, but there are local peaks rising higher than 10,000 ft.

Surface roughness of the light areas, which are essentially flat at low scale, appear to vary between five microns and two meters. In contrast, the dark areas appear to contain concave and convex surfaces with radii of curvature varying between 10 cm. and infinity.

Since dark areas are usually assumed to hold the highest biological interest, these are designated prime landing areas for a *Voyager* capsule. However, surface concavities there and downslope winds of about 180 fps result in predicted capsule landing shocks from 1,290 to 2,450 g's.

Initially, the high-impact program used an upper velocity limit of 200 fps, the impact velocity of proposed *Ranger* lunar hard landers. When this program was eliminated, tests were adjusted to the requirements for the *Surveyor* critical data recorder. The *Voyager* program has now raised the impact velocity for which survivable equipment is being designed to 500 fps.

Industry effort—Philco Corp.'s Aeronutronic Div. has also been concerned with high-impact system development. Two years ago, it produced a balsa-wood sphere that carried a facsimile system. Intended for the *Ranger* program, it was designed to return pictures of the lunar surface after impacting at up to 3,000 g's. Aeronutronic is now looking at alternatives to balsa for impacts of up to 10,000 g's investigating the problems of landing an automated biological laboratory on Mars.

The company has also successfully tested complete electronic circuits at impacts of 10,000 g's in developing a lunar penetrometer for NASA.

According to J. L. Adams of JPL, specific equipment being developed there to survive the 10,000-g impact at 500 fps includes a gas chromatograph, a three-watt S-band transmitter, flat-plate batteries and S-band antennas. At the same time, electronic packaging techniques and electronic components are being screened for impact resistance. The chromatograph, transmitter and batteries would provide a minimum system for complete lander impact tests.

Realistic tests of equipment are provided by compressed air guns, with bores of 3, 6 and 22 in. These fire the equipment at velocities up to 500 fps into targets capable of providing suitable g-profiles. Facilities remaining from the early part of the program include a drop tower providing velocities up to 50 fps and a horizontal impact machine giving velocities of up to 200 fps. This latter can provide a rectangular acceleration-versus-time curve of 10,000-g peak lasting about two-thirds millisecond.

Gas detector—Ruggedization of a gas chromatograph is currently a joint development program of JPL's Engineering Mechanics Div. and Space Sciences Div. The unit is intended to detect argon, nitrogen and carbon dioxide in the Martian atmosphere. It is being put through graduated impact tests; weak points are strengthened as they are revealed. Electronic components are mounted on printed circuit boards, with the heavier components spot-bonded in place. The board is coated with a polyurethane compound (Solithane 113-300) that has been shown effective as a support for components under impact. All instrument plumbing is integral with the main structure, with the exception of the supply-line from the carrier gas bottle.

The work on the gas chromatograph has involved the development of an impact-resistant pressure regulator and sampler valve. These mechanisms would

Air Force Comsat Readied for Summer Launch

A new kind of communications satellite that will be launched by the Air Force in July is shown fully inflated. Developed by Goodyear Aerospace Corp., the 30-ft.-dia. sphere is made of fine wire grid and a new material that photolyzes when it encounters the Sun's ultraviolet rays in the vacuum of space. The wire grid remains and acts as a reflector for radio waves.

be suitable for other types of instrument. Small electric motors with spring-mounted bearings able to withstand 10,000-g impacts from 200 fps in radial and axial directions have also been produced. The same bearings could also find possible application in a hard-landed turbo-alternator secondary power source. A turbine running at about 30,000 rpm in spring-mounted bearings was impacted at 10,000 g's from 165 fps. It continued running; subsequent examination showed no significant bearing damage.

S-band equipment—JPL's Telecommunications Div. and EMD are cooperating in the development of the S-band transmitter. This has a total weight of 2 lbs. and is packaged in three modules. Two of the modules have survived 10,000 g's at 180 fps. The third, consisting of two frequency doublers, is still in the circuit development stage but is not expected to be susceptible to impact since it uses stripline techniques. Chief difficulty in hardening the transmitter was in obtaining impact-resistant crystals.

A ruggedized turnstile S-band antenna for the transmitter has been through 9,000 g's from a velocity of 170 fps with no significant damage.

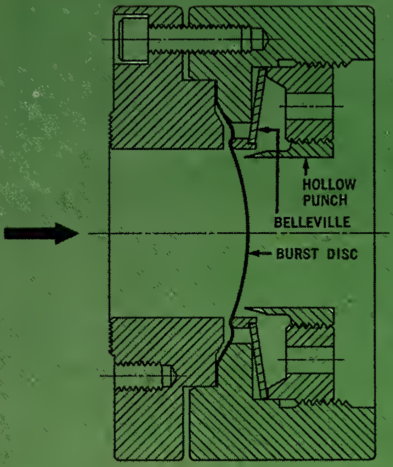
Chief activity in impact-resistant battery development has been evaluation of off-the-shelf units. Joint work by JPL's Guidance and Control Div. and EMD indicates that suitable batteries can be made with conventional plate and separator techniques, provided that cases and internal potting can give adequately rigid support. Chief activity at present is development of improved case designs and potting techniques.

Tests of capacitors, resistors, diodes and transistors showed that many of the types available can resist 10,000-g impact. Tests of a small sample of integrated circuit flat packs showed that all could survive 7,000 g's. Devices developed by Signetics Corp., Texas Instruments, Inc., and Motorola Corp. were tested and also performed satisfactorily electrically after a 12,500-g impact.

Better packaging—JPL found early in the program that circuits constructed with terminal boards or printed circuit boards could be made to withstand high-g impacts. Now attention is being turned to more efficient packing techniques. A functional *Mariner* Mars welded module was potted in a cavity and impacted at 7,500 g's from 170 fps and continued to perform electrically. The unit failed at 10,000 g's when a 2N861 transistor that was not impact resistant failed.

According to Adams, the welded module technique appears fully adequate for impacts up to 10,000 g's. ■

Burst Discs to 12″ port sizes give instantaneous full flow



Burst disc assemblies from ¼″ to 12″ port sizes allow system operation within 95% of rupture ratings. Units can be supplied to operate at temperatures from −423° to + 1000°F.

Before shipment, each assembly is set to an accuracy of 1% and pre-tested for rupture without damage to the burst diaphragm.

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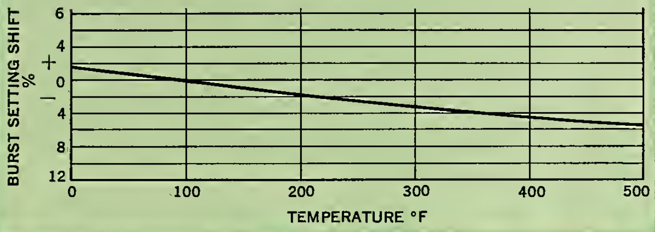
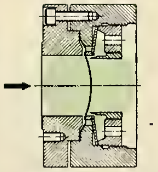
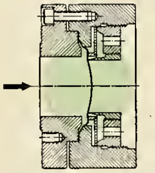
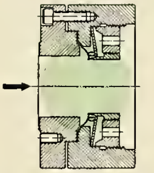


In Calmec burst disc assemblies, accuracy depends on modulus of elasticity of a spring member rather than ultimate strength; therefore, burst variation due to temperature change is very slight. Temperature compensated models with virtually zero shift in rupture setting can be furnished when desired.

SEQUENCE OF OPERATIONS


Normal Position—Belleville spring provides partial backup of diaphragm; adjustment of spring permits accurate calibration of burst setting.


During Snap-Over — Burst diaphragm in contact with punch during snap-over of Belleville spring; pre-loading assures burst at desired pressure.


Full Diaphragm Shear—Belleville spring in snap-over position, complete rupture of burst disc center portion assures full flow area instantaneously.

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Automatic Chemical Processor Tested

by Heather M. David

NEWPORT BEACH, CALIF.—Scientists at Philco Corp.'s Aeronutronic Div. are developing an automatic chemical-processing subsystem that will combine a large number of functions in an experimental life-detection probe.

A breadboard model of the system has been tested and development of a prototype flight model appears feasible, Philco scientists Donald C. Garwood and Harry A. Taussig reported recently.

The function of the processor is to prepare raw specimens in the proper form so that they can be analyzed by a final instrument such as a chromatograph or spectrometer. The Philco scientists figure that there are about 16 elemental processing operations with which almost all biochemical-detection experiments can be performed.

These processes include such things as adding a liquid to a solid, mixing or separating liquid/solid phases, concentrating liquid by evaporation, condensing vapor, dialysis or ultrafiltration, adding miscible or immiscible liquids to other liquids, mixing miscible or immiscible liquids, heating, cooling, timing and the like.

With the proper reagents, some 100 or more complex biochemical analyses could be performed, the scientists say. The system could be used in conjunction with a fully automated biological laboratory, or it could be transported by astronauts to the Moon or Mars, freeing them for experimental duties which require human presence. The Philco scientists also noted that the processor has application to Earth-bound laboratories, where it could take over routine work.

How it functions—Batch processing was selected over a continuous-flow process because of the large amounts of fluid needed to keep the latter functioning, and because of the relative inflexibility of the continuous-flow cycle.

Batch processing, the scientists said, can be designed to work intermittently and on command, and with small amounts of material. However, batch-processing equipment has the disadvantage of needing to be cleaned out after every processing operation.

The breadboard system tested by the Aeronutronic group was designed to perform six elemental processing operations to demonstrate the concept: addition of a liquid; agitation of a liquid and a solid; agitation of a liquid and a liquid; addition of a gas to a liquid; separation of solid and liquid phases (filtration); and separation of immiscible liquids.

The heart of the system is the reaction chamber, a cylinder in which all chemical reactions are contained and which can be cleaned after every process. An outside piston device introduces a specimen into a filter unit located directly above a suction unit and feed mechanism. This device can apply suction to the filter unit or force a liquid through the reaction chamber, where liquids are drawn off for analysis.

A piston assembly is also placed at the top of the reaction chamber. This piston can be moved in conjunction with the piston in the suction unit, applying pressure to aid filtration; the piston also can be moved downward after a process is concluded to clean off the walls of the reaction chamber. A clean tip automatically replaces the used tip after this operation.

Reagents are introduced from ampules fed at the top of the reaction chamber. Each ampule is used only once. Transfer ampules also are supplied to remove liquid from the chamber. Feedlines supply wash water, cleaning solutions and gases in bulk supply. Gases are removed through a port on the edge of the chamber and stored for analysis.

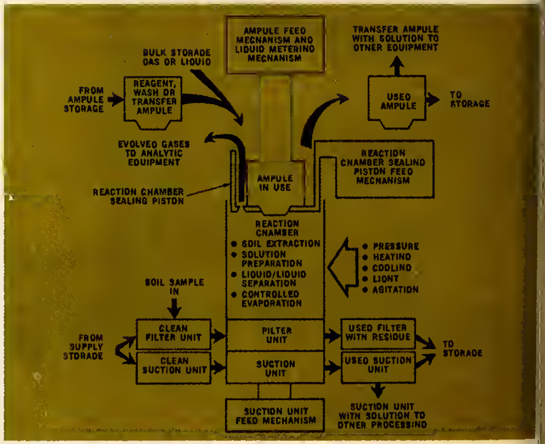
Agitation or mixing can be accomplished by two methods, the scientists say. The first is by using a nozzle assembly, which doubles as a wash ampule, or by activating a ring of nozzles in the filter unit. Ancillary equipment is provided in the system to speed chemical reactions, for distillation, for fusions or for pyrolisis of organic materials.

The scientists pointed out that the requirement for sterilization must be met by the system—that is, dry-heat sterilization at 125°C or higher for periods of several days. This results in a restricted list of materials which can be used in fabricating the system, but this is not an insurmountable problem. For instance, materials such as Teflon, Viton, stainless steel, commercially pure nickel, and Pyrex or fused silica glasses are likely candidates, the scientists suggested.

Automatic system—The Philco group also demonstrated in the breadboard model the feasibility of constructing the automatic system. They report successful operation of what they consider the most difficult or complex set of manual steps—namely, the handling of the reagent ampules, including the locking seating, and reagent-metering from the ampules, plus the reverse steps of returning the reagent for storage. This automatic operation, a series of ten steps, has been accomplished.

The group also points out that the equipment will be useful for environments which do not lend themselves to direct human exploration; *e.g.,* high-radiation environments, the high-thermal environment found on Venus, or the high-pressure environment of the ocean floor. ∎

Block flow diagram of processor. Soil sample and clean suction unit would be placed in filter unit and clamped to bottom of reaction chamber. The reagent ampule would be positioned, lowered and seated against the inside of the piston. When the chamber is sealed with piston, the seal on the ampule would be broken by pushing down so that the needle perforates.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TO STORAGE
EVOLVED GASES TO ANALYTIC EQUIPMENT
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AMPULE IN USE
REACTION CHAMBER SEALING PISTON
REACTION CHAMBER
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• LIQUID/LIQUID SEPARATION
• CONTROLLED EVAPORATION
• PRESSURE
• HEATING
• COOLING
• LIGHT
• AGITATION
SOIL SAMPLE IN
FROM SUPPLY STORAGE
CLEAN FILTER UNIT
CLEAN SUCTION UNIT
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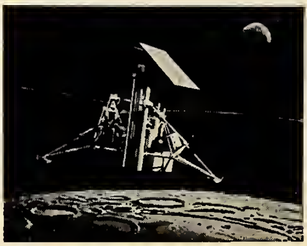

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The Industry Week

Mergers and Acquisitions

The Cosmodyne Corp., Torrance, Calif., has acquired the assets and business of Ryan Industries, Cleveland. Cosmodyne manufactures cryogenic equipment and systems. Ryan, which produces cryogenic storage vessels and containers, will be operated as a wholly owned subsidiary of Cosmodyne. . . . *General Aniline & Film Corp., New York City, has purchased three chemical manufacturing companies. They are Burkart-Schier Chemical Co. and Southeast Polymers, Inc., both of Chattanooga, Tenn., and Checkmate Chemicals, Inc., Greenville, S.C.* . . . Stockholders of Itek Corp., Lexington, Mass., have approved purchase of the Pennsylvania Optical Co., Reading, Pa. . . . *Shareholders of International Telephone and Telegraph Corp. will meet in Baltimore on April 27 to vote on a planned merger with American Broadcasting Companies, Inc.*

International

Atomic Energy of Canada, Ltd., Ottawa, has approved a proposal by Canadian General Electric Co. to construct a plant to produce heavy water at a rate of 500 tons a year. The new plant would more than triple planned production of heavy water for Canada's nuclear industry. Production is scheduled to begin by mid-1969. . . . *FMC Corp., San Jose, Calif., has purchased an undisclosed number of shares of Foret, S.A., Barcelona, Spain, an inorganic chemical producer.* . . . Motorola Semiconductor Products, Inc., Phoenix, Ariz., plans to form a new corporation near Toulouse, France, to manufacture a complete line of semiconductor products. Occupancy of the plant is scheduled to begin in late 1967. . . . *Selenia, S.p.A., Italian affiliate of the Raytheon Co., Lexington, Mass., will supply a microwave system for two new tactical air defense systems to be built for the Royal Australian Air Force.*

Thiokol To Operate Job Corps Center

Thiokol Chemical Corp. will operate an urban Job Corps center for men in Clearfield, Utah, under an initial 15-month $12.8-million contract from the Office of Economic Opportunity. In addition to standard courses, applicants will receive training in chemical and plastics processing, automotive and small engine repair, air conditioning and heating repair, food services, medical and veterinary fields.

In the Courts

Hexcel Products, Inc., Berkeley, Calif., and American Cyanamid Co., Wayne, N.J., have announced a settlement of trade secret and patent litigation regarding manufacture and sale of aerospace honeycomb core materials. The action was initiated by Hexcel in 1964 in the Federal court in Baltimore. Under the agreement, Cyanamid will make payments to Hexcel for a license for use of certain technical information and certain Hexcel patents. Both firms will continue to produce the material.

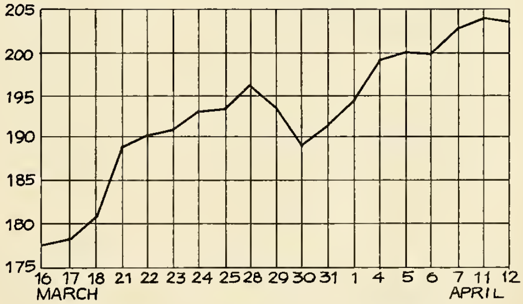
Industry Facilities

Avco Corp., New York City, plans to open a new plant in Charleston, S.C. The facility will allow the firm to expand its activities in the industrial and marine gas turbine fields. The firm has also announced plans to lease 40,000 sq. ft. of additional space at its Lycoming Div., Stratford, Conn. . . . *Applied Technology, Inc., Palo Alto, Calif., is planning a 50% enlargement of its production manufacturing facilities in Sunnyvale, Calif., This will give the plant a total of 33,000 sq. ft.* . . . Lockheed Propulsion Co. has announced a production facilities expansion program in Redlands, Calif. The $2.5-million program is a result of studies aimed at increasing capacity and reducing costs in production of rocket motor cases and associated hardware. Construction and equipment acquisition are expected to be completed by September. . . . *OKI Electronics of America, New York City, has opened a new laboratory in Fort Lauderdale, Fla. The facility will be used for development and testing of millimeter-wave generating devices and systems.* . . . Rocketdyne Div. of North American Aviation, Inc., Canoga Park, Calif., has activated a new high-pressure test facility at the division's Nevada Field Laboratory in Reno. The facility will provide a capability to test full-scale engines and components of advanced design at operating pressures up to three times those for present engines, the company said.

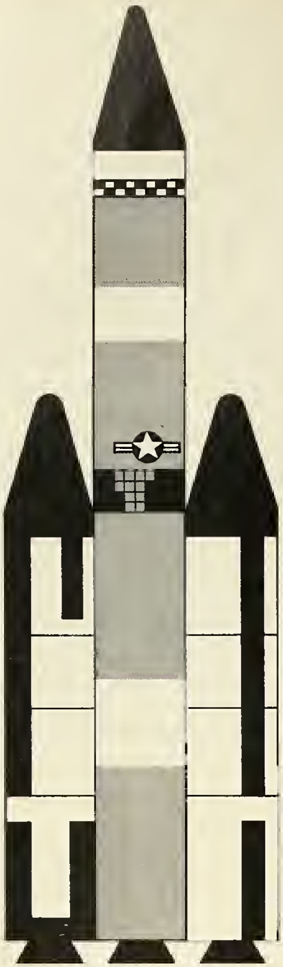
Company Representatives

Polytronics Laboratories, Inc., Silver Spring, Md., a subsidiary of Vitro Corp. of America, has named DiBlasi Associates, Port Washington, N.Y., to represent the firm in New York City, Long Island, Westchester and lower New York state. . . . *Liquidonics, Inc., Westbury, N.Y., has announced two new distributors for its line of hydraulic and pneumatic components. Fluid Power Div., of Mobesco, Inc., Atlanta, Ga., will operate in Georgia and eastern Tennessee. S. G. Morris Co., Inc., Cleveland, will represent the firm in West Virginia and parts of Ohio and Pennsylvania.*

Missile/Space Stock Index



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH



Missiles & Rockets will publish a Special Report on the U.S. Military Space Program on May 30, 1966. Reserve your advertising now —

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Contracts

AIR FORCE

$7,568,000—**Martin Marietta Corp.**, Denver, Colo., increment to an existing contract for design, development, fabrication and delivery of a *Titan III* space booster and associated equipment.

$3,500,000—**Avco Corp.**, New York City, first segment of a $63,585,300 contract for development and production of Mark 17 re-entry vehicles.

$3,200,000—**Lear Siegler, Inc.**, Santa Monica, Calif., for production of attitude reference and bombing computer systems for use aboard the F-4, Phantom II aircraft.

$2,000,000—**McDonnell Aircraft Corp.**, St. Louis, Mo., increment to a previously awarded contract for work on the *Manned Orbiting Laboratory*.

$1,249,845—**F&M Systems Co.**, Dallas, to provide two mobile, air-transportable, closed-circuit-television recording facilities for tactical use by the Air Photographic and Charting Service.

$1,200,000—**TRW, Inc.**, Redondo Beach, Calif., initial increment to a $3,000,000 contract for production of airborne tactical reconnaissance equipment.

$540,000—**Sperry Rand Corp.**, Gainesville, Fla., for microwave tubes.

$127,755—**Clevite Corp.**, Cleveland, Ohio, for work on a material used in rocket nozzles.

ARMY

$2,800,000—**General Time Corp.**, New York City, an additional contract for precision Army ordnance devices.

$2,675,792—**Hercules Powder Co.**, Wilmington, Del., modification to an existing contract for miscellaneous propellants and explosives.

$2,500,000—**Sylvania Electric Products, Inc.**, Needham, Mass., modification to an existing contract for classified electronic equipment.

$1,599,066—**Lehigh, Inc.**, Easton, Pa., fixed-price contract for 2.75-in. rocket warheads.

$1,500,000—**General Telephone & Electronics Corp.**, Needham, Mass., for electronic communications equipment.

$1,476,300—**American Manufacturing Co.**, Fort Worth, Tex., fixed-price contract for 2.75-in. rocket warheads.

$1,373,716—**General Time Corp.**, Westclock Div., LaSalle, Ill., fixed-price contract for 2.75-in. rocket fuzes.

$1,338,900—**Bulova Watch Co.**, Jackson Heights, N.Y., fixed-price contract for 2.75-in. rocket fuzes.

$1,296,841—**Hamilton Watch Co.**, Lancaster, Pa., fixed-price contract for 2.75-in. rocket fuzes.

$1,264,128—**Avco Corp.**, Richmond, Ind., fixed-price contract for 2.75-in. rocket fuzes.

$1,235,807—**KDI Corp.**, Cincinnati, Ohio, fixed-price contract for 2.75-in. rocket fuzes.

$1,198,702—**Gibbs Manufacturing & Research Corp.**, Janesville, Wis., fixed-price contract for rocket fuzes.

$1,093,552—**Philco Corp.**, Newport Beach, Calif., contract modification for various quantities of spare parts for the *Shillelagh* missile system.

$1,031,000—**Atlantic Research Corp.**, Ordnance Div., West Hanover, Mass., for bomb cases and fuze assemblies.

United Aircraft Corp., Norden Div., Norwalk, Conn., for development of a feasibility model of an airborne ground-fire locator system that will provide a visual display of the location of the weapon and generate an audible alarm through the intercom on the aircraft. Amount not disclosed.

NAVY

$4,797,000—**Chromcraft Corp.**, St. Louis, Mo., to manufacture rocket launchers.

$3,962,122—**Hazeltine Corp.**, Braintree, Mass., for sonar equipment.

$1,828,950—**Thiokol Chemical Corp.**, Reaction Motors Div., Denville, N.J., for *Bullpup* rocket engines.

$1,780,300—**Magnavox Co.**, Fort Wayne, Ind., cost-plus-incentive-fee contract for work on a classified project.

$1,000,000—**Westinghouse Electric Corp.**, Sunnyvale, Calif., letter of intent with a limit authorization through Fiscal Year 1966 for development of the *Poseidon* missile launcher system.

$408,383—**B.F. Goodrich Co.**, Shelton, Conn., for construction of a microwave anechoic chamber.

North American Aviation, Inc., Columbus Div., Columbus, Ohio, to develop the *Condor* air-to-surface, television-guided missile. Amount not disclosed.

NASA

$7,634,742—**North American Aviation, Inc.**, Canoga Park, Calif., modification of an existing contract to produce H1 rocket engines for the *Saturn IB*.

$88,000—**Martin Co.**, Denver, Colo., from Marshall Space Flight Center to continue design and development of advanced space vehicle control systems.

$51,000—**Martin Co.**, Denver, Colo., to study the relative merits of horizontal and vertical take-off of reusable space vehicle systems.

INDUSTRY

$7,000,000—**Dynamics Corp. of America**, New York City, from **Page Communications Labs, Inc.**, Washington, D.C., to manufacture solid-state, atmospheric-scatter communications equipment for the Army.

$5,000,000—**Northrop Corp.**, Beverly Hills, Calif., from **Raytheon Co.**, Lexington, Mass., fo missile ground-handling equipment and airframe components for *Hawk* surface-to-ai missile systems for Saudi Arabia.

$2,380,000—**Defense Electronics, Inc.**, Rockville Md., from the **Bendix Corp.**, Detroit, Mich. for telemetry equipment for the *Apollo* airborne tracking aircraft.

$1,796,900—**Varian Associates**, Palo Alto, Calif. from **Oak Ridge National Lab**, Oak Ridge Tenn., to design, fabricate and make operational the electron linear accelerator.

$1,600,000—**Rohr Corp.**, Chula Vista, Calif., fro **Sylvania Electric Products, Inc.**, Needham Mass., for construction of two 85-ft.-dia. antennas for installation at Comsat Corp. groun stations in Brewster Flat, Wash., and Paumalu Hawaii.

$1,000,000—**HITCO**, Gardena, Calif., from **Bliss Portland Co.**, Portland, Maine, for manufactur and assembly of nozzle components for th first-stage *Minuteman*.

$1,000,000—**Whittaker Corp.**, Chatsworth, Calif. from the **Boeing Co.**, Seattle, Wash., to suppl valves for use in the first stage of the *Satur V* Moon rocket.

$1,000,000—**Bendix Corp.**, Friez Instrument Div. Towson, Md., from the **Westinghouse Electri Corp.**, Defense and Space Div., Baltimore, fo power supply assemblies.

$645,840—**Borg-Warner Corp.**, Van Nuys, Calif. from **Martin Co.**, Orlando, Fla., to design an manufacture the electro-hydraulic servo control system for the *Walleye*.

$310,000—**Talley Industries**, Mesa, Ariz., fro **Boeing Co.**, Seattle, Wash., for launcher closur actuators and umbilical actuators for th *Minuteman II* missile program.

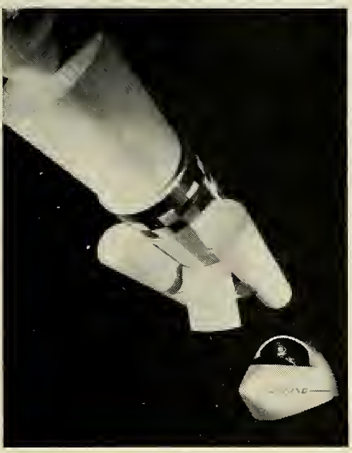
$222,947—**R.C. Allen Business Machine Co** Grand Rapids, Mich., from the **Martin Co** Orlando, Fla., to supply roll gyros for th *Walleye*.

$202,000—**Beckman Instruments, Inc.**, Fullerto Calif., from the **Royal Swedish Air Forc Board** for a high-speed data-processing syste to be used by the Aeronautical Research Inst tute of Sweden initially for high-velocity win tunnel tests.

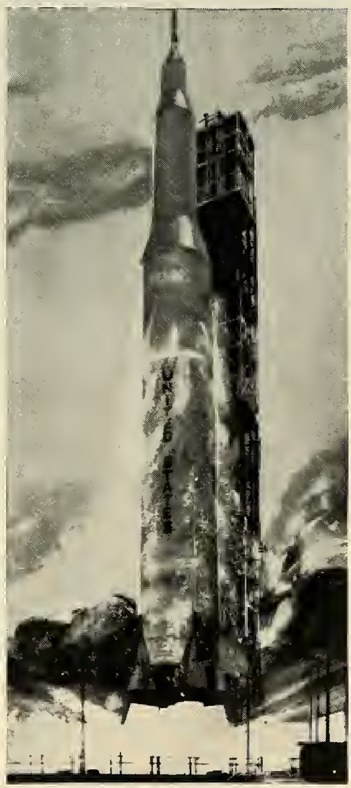
$138,000—**Ladish Co.**, Los Angeles, from th **Boeing Co.**, Seattle, Wash., for forged alum num rings for the *Minuteman II*.

$117,180—**Argus, Inc.**, Ann Arbor, Mich., fro the **Martin Co.**, Orlando, Fla., for the gui ance lens and window for the *Walleye*.

Engineers and Scientists: Your future is at Boeing. Now.



Rendezvous and docking simulations experiments being conducted at the Boeing Space Center, most advanced space research facility in private industry.



160,000,000 horsepower, equivalent to power of 600,000 automobiles, will be generated by S-1C first-stage booster as NASA's Saturn V lifts Apollo off on moon journey.

First Lunar Orbiter flight, scheduled for mid-1966, will seek out Apollo landing sites with sharp, detailed photographs of moon's surface. Boeing is building eight Orbiters for NASA.

The Boeing Company's deep involvement in the nation's most important missile and space programs is providing qualified engineers and scientists career opportunities of unusual scope and growth potential. Boeing currently is weapon system integrator for the U.S. Air Force advanced Minuteman II ICBM, prime contractor for the National Aeronautics and Space Administration Lunar Orbiter moon-scanning satellite, and a major contractor on the NASA Apollo/Saturn V program.

Aerospace Group assignments, listed in the right-hand column, are in research, design, development, manufacturing and test, and scientific and business computer technology. Requirements include a Bachelor's or advanced degree in an applicable discipline, plus related experience.

Salaries are competitively commensurate with experience and educational background. Moving and travel allowances are paid to newly hired personnel. The Boeing Company is an equal opportunity employer.

Send your resume to the employment manager at the installation(s) of your choice: Mr. L. S. Bonsteel, Boeing Atlantic Test Center, P. O. Box 1698 - MTV, Cocoa Beach, Florida; Mr. John Hall, Boeing Launch Systems Branch, P. O. Box 1680 - MTV, Huntsville, Alabama; Mr. R. A. Garinger, Boeing Launch Systems Branch, P. O. Box 29100 - MTV, New Orleans, Louisiana 70129, or Mr. Robert Laurie, The Boeing Company, P. O. Box 3822 - MTV, Seattle, Washington 98124.

BOEING

Missile & Information Systems Division
Space Division

Assignments are in the following areas:

Aerospace Program Planning
Arming & Fuzing Technology
Brazing/Diffusion Bonding
Computer & Logic Circuit Development
Computer Systems Analysis
Cryogenics
Electrical/Electronic Design
Electronic/Electromechanical Parts Evaluation
Electronics Technology
Flight Technology
Guidance & Control
Industrial Engineering/PERT
Instrumentation
Logistics Engineering
Management Systems Staff
Manufacturing Development
Materials & Processes
Mechanical Design
Plant Facilities Engineering
Propulsion & Mechanical Systems
Quality Control
Reliability
Scientific Computer Programming
Service Engineering
Structures Analysis & Design
Systems Engineering
Telemetry Systems & Design
Test Engineering
Tool Design
Weights Engineering
Welding Process Development

Other Divisions: Commercial Airplane • Supersonic Transport • Vertol • Wichita • Also Boeing Scientific Reseach Laboratories

New Product of the Week:

High-Vacuum Evaporator

An evaporator for producing thin-film deposition coatings in a clean, high-vacuum environment has been announced by Bendix-Balzers Vacuum, Inc.

Model BA-510 is a complete, high-speed packaged system. Standard optional accessories include single or multiple electron beam sources, an eight-position mask-substrate changer, optical and conductance thin-film monitors, a glow discharge, a rotary cage, and others.

Cycling time with liquid nitrogen to less than 5 x 10^{-8} torr is achieved in the 20-in.-dia. bell jar. The unit uses a BBV 1850-liter/second oil-diffusion pumping system, made failsafe with an interlocked single-lever sequenced valved control. Highest pumping speed at the port is rated at 625 liters per second.

Circle No. 151 on Subscriber Service Card

Industrial Furnace

A furnace claimed to be the first to feature three separate temperature zones with five individual zones of control has been introduced by Marshall Products.

Model 804-C can attain a temperature separation between zones of up to 200°C in four to six inches. Temperatures of individual zones are maintained within 1½°C. Linear gradient temperature profiles up to 50°C per inch can also be realized utilizing shunt tap provisions. Water cooling coils permit sharper gradients between the flat zones.

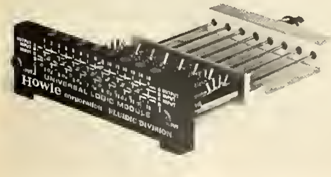
Circle No. 152 on Subscriber Service Card

Fluidic Logic Module

A fluidic logic module that is claimed to eliminate the problems of manifolding, fan-outs, and long runs of tubing and mounting has been announced by Fluidic Div., Howie Corp.

With the module, the logic portion of a system can be wired and tested before insertion into the system. Standard logic functions can be pre-wired and stored for use when needed.

Each module contains eight turbulence amplifiers with a supply and an output manifold. On the front of the manifold are 16 output terminals; 14 input terminals supply input signals to the module. The front of each logic panel is coded.



Circle No. 153 on Subscriber Service Card

Power Monitor

A power monitor that provides over/under voltage and current alarm or control has been announced by Controlotron Corp.

Model 440-1 is a completely solid-state device that monitors the voltage and current supplied from a power source or to a power load. In the event that either the voltage or current exceeds a predetermined value, an alarm is actuated and automatic shutdown of power can be initiated. Accuracies of up to 0.1% in both voltage and current alarm levels are available, the company says.

Alarm voltage levels of 5 to 1,500 v and alarm currents from 1 to 1,000 amp. can be provided, with a safe overload of up to 500%. Built-in transient protection and noise filtering are provided and automatic or manual alarm reset is available. Overvoltage is sensed by a balanced amplifier detector in conjunction with a temperature-stabilized Zener diode reference. Overcurrent is detected by a balanced amplifier circuit operating in conjunction with specially designed current sensors.

The unit is qualified to military specification MIL-E-5272C, including the temperature range from —55° to 150°C.

Circle No. 154 on Subscriber Service Card

Laser Measurer

Development of a laser distance-measuring device with an accuracy of a fraction of an inch per mile has been announced by Spectra-Physics.

The instrument uses a modulated light beam from a continuous-wave gas laser and provides analog or digital readout of phase-difference comparisons between transmitted and returned beams. Digital readout resolution is claimed to be 0.001 ft.; readout can also be obtained in metric units. Separate electronic and optical packages are included in the design and the unit can be set up in the field by one man.

Measurements can be made from point to point on the ground, ground to air, or shore to ship. The instrument is suited for first-order geodetic surveys at distances of more than 50 miles, and may also be used as an altimeter or altimeter calibrator.

Circle No. 155 on Subscriber Service Card

Frequency-to-DC Converter

A frequency-to-dc converter that provides both regulated voltage and current outputs over a wide range of input frequencies has been introduced by Anadex Instruments Inc.

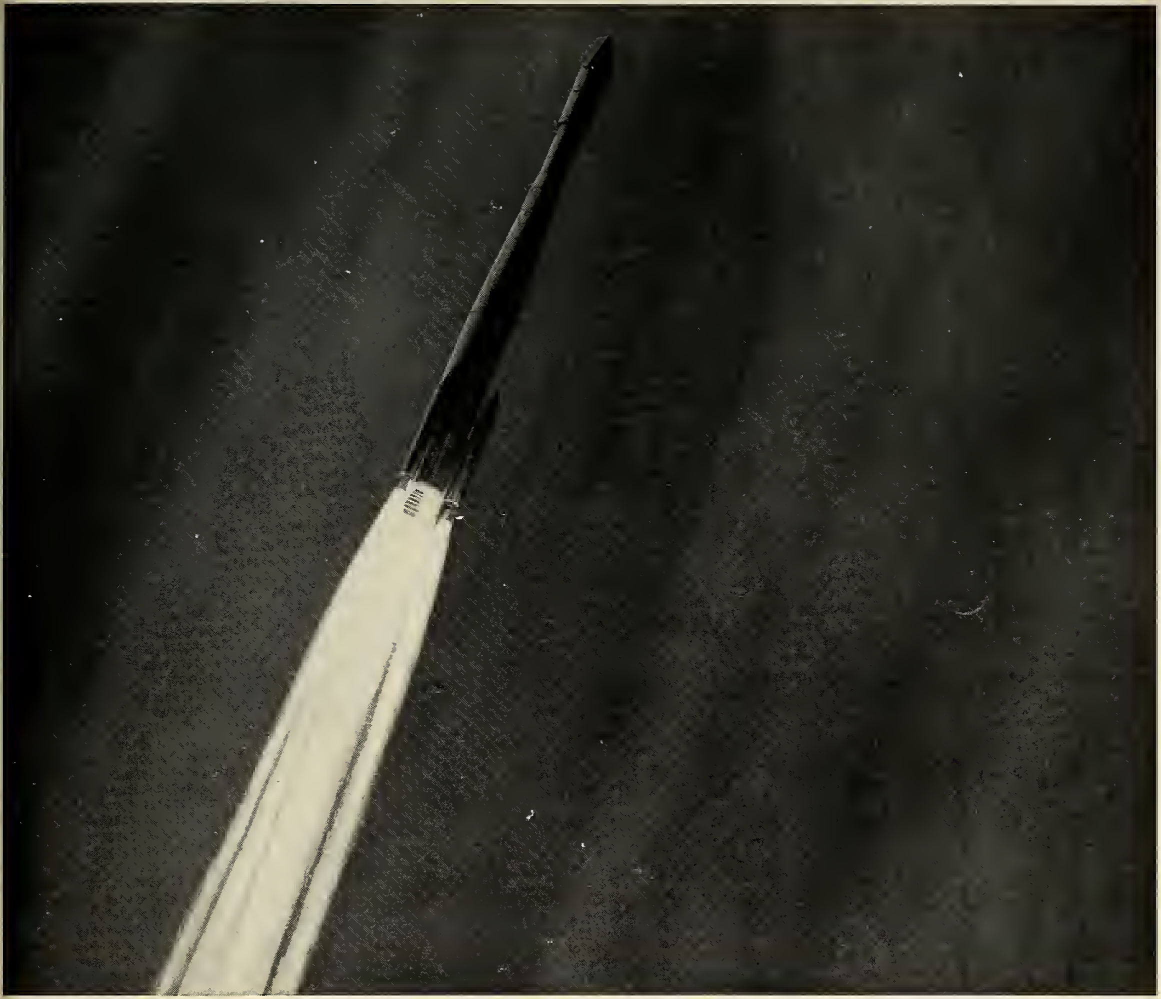
Model PI-600 is designed for industrial applications for flow rate or speed monitoring and control. Full-scale input frequencies are adjustable from 250 to 3,000 cps. Three full-scale outputs are provided: 0 to 5 v, 1 to 5 ma, and 4 to 20 ma. Input is transformer-coupled and the device will accept sine waves, square waves, or pulses.

Common-mode rejection and sensitivity of 0.01 vrms are featured; linearity is better than ±0.5%.

Circle No. 156 on Subscriber Service Card

Dielectric Material

A thermoplastic of electrical-grade polyphenylene oxide for use in strip-line circuitry and microwave printed-circuit



Douglas Delta: now a bigger, better booster

The Douglas Delta holds the world's record of consecutive satellite boosts without a failure. It has orbited every non-military weather and communications satellite launched in the free world.

Now Douglas and the National Aeronautics and Space Administration have improved it for even greater space achievements. They've added solid fuel rockets for more initial boost and increased fuel capacity for longer firing time during second-stage boost.

Result: The improved Delta can earth-orbit more than 1400 pounds and lunar-orbit more than 220 pounds–and launch several satellites at one time.

DOUGLAS
MISSILE AND SPACE SYSTEMS DIVISION
gets things done

design has been introduced by the Polymer Corp.

The Z-tron "G" dielectric material combines the strength, rigidity, and thermal and dimensional stability of thermosets with the low electrical loss characteristics of thermoplastic olefins, according to the firm.

When operating within its temperature range of —270° to 375°F, the low linear coefficient of thermal expansion of the material is claimed to prevent thermally induced stresses, rupture of copper cicuitry, or loss of bond.

The material is available, copper-clad and un-clad, in sheets up to 16 x 24 in. and in thicknesses of 0.0625 to 0.250 in. Standard thicknesses are held to a tolerance of ± 0.001 in.

Circle No. 157 on Subscriber Service Card

Shock Testing System

A modular shock testing system for military, space vehicle and commercial applications has been introduced by Monterey Research Laboratory, Inc.

The IMPAC system consists of 17 modules which can be assembled into 14 different machine configurations to suit test requirements. One lifting and guiding system is used with five different tables and five reaction masses. A high-velocity acceleration kit is added for pulses that cannot be achieved with a free fall. An integrated control and instrumentation console is also available.

The system is designed to test 200-lb. specimens up to 5,000 g's and 2,000-lb. specimens up to 1,000 g's.

Circle No. 158 on Subscriber Service Card

Tape Reader/Reeler

A photoelectric paper-tape reader/reeler that reads opaque tapes asynchronously at speeds up to 125 characters per second has been announced by Omni-Data Div. of Borg-Warner Corp.

Model PTR-60100 contains an integral companion reeler that handles tape in the forward mode at maximum reading speed, and in the rewind mode from 20 to 40 in./sec. Only a step-pulse need be provided by the user and there are no controls to set or adjustments to make. If the user's system has stop-code logic, a rewind stop can be transmitted to stop the tape within 50 millisec.

The unit incorporates nine channels of amplification, tape drive control, reeler control, and positive interlocks for taut-tape and out-of-tape control.

Circle No. 159 on Subscriber Service Card

Microphone Calibrator

A variable frequency microphone calibrator that can be used as a standard reference for sound pressure calibration in aircraft, aerospace, electronics, and applied science laboratories is being marketed by Bolt Beranek & Newman, Inc.

Model 901D is capable of generating precise sound pressures at low frequency and at high levels, with an accuracy of ± 0.2 db. Two interchangeable-drive modules are available to provide sound pressure levels from 110 db to 170 db pressure in precise 10-db steps, with a common checkpoint between modules at 140 db. The frequency range covered is from 3 to 200 cps.

The instrument operates on 60-cycle, a-c power and from an ordinary plant air outlet. Most commercial microphones can be calibrated through the use of four adapters, and adapters for others can be supplied.

Circle No. 160 on Subscriber Service Card

Aerial Exposure Computer

An aerial exposure computer for color and black-and-white aerial photography has been announced by Eastman Kodak Co.

Dial calculators in the computer provide accurate exposure for most commonly used Kodak aerial films as well as for new high-definition, high-resolution films under aerial exposure conditions anywhere in the world, the firm says.

The exposure guide enables interrelation of such factors as aircraft ground speed, lens focal length, image motion on film, solar altitude, latitudes, haze conditions, exposure times, and filtration when calculating exposures for aerial photography.

The unit may be used to determine image velocity, ground distance covered, and total image motion on film when these factors are not known. A latitude zone map, solar altitude tables, and latest aerial film exposure indices ranging from 0.6 to 640 aerial exposure index are included.

Circle No. 161 on Subscriber Service Card

Measuring Counter

A counter/plug-in system that makes automatic and direct-reading microwave measurements in the range from 500 MHz to 12.4 GHz is being marketed by Systron-Donner Corp.

The portable instrument consists of a basic 50-MHz or 100-MHz counter and three interchangeable ACTO plug-ins that progressively extend the counter's measuring range from 500 MHz to 12.4 GHz.

When installed into the front area of the basic counter, the plug-in accepts an input signal, phase-locks a harmonic of an internally swept oscillator, and automatically adjusts the counter time base to achieve direct readout—all within milliseconds. Signal input sensitivity is said to be better than —7 dbm (100 mv rms).

Circle No. 162 on Subscriber Service Card

Digital Computer

A line of digital computers for military applications has been introduced by Raytheon Co.'s Missile Systems Div.

The Model R-11 features a memory of 950 microsec., a full memory cycle and an 8,192-word memory with 24 bits plus parity per word. Enclosed in its 1.9-cu.-ft. package are the memory unit, a central data processor, and a power supply available in both 60- and 400-cycle models. The system is capable of performing high-speed arithmetic operations, including multiplication of two 24-bit words in 5.6 microsec., plus all necessary memory accesses and register transfers. Two 24-bit words can be added or subtracted in 1.9 microsec.

Seventy commands are available, including arithmetic, transfer, store, logical and shift functions. The computer features memory data protection in case of power failure, and real-time inputting at 25 megabits per second.

Circle No. 163 on Subscriber Service Card

Hydraulic Vibrator

A hydraulic vibrator employing a fluid that changes density when voltage is applied to it has been developed by The Boeing Co.

Each vibrator is 32-in. long; several can be joined together to permit large assemblies to be vibration-tested. The output shaft moves in one direction when an electrical field in certain chambers of the vibrator thickens the hydraulic fluid, causing pressure to build within these chambers. Changing voltage to opposite chambers in the unit releases the original pressure and produces a new buildup of pressure in the opposite direction. The shaft responds by moving in the opposite direction.

Tests have produced 3,500 lbs. of static force at 1,000 cps.

Circle No. 164 on Subscriber Service Card

Piston Pump

An in-line piston pump for aerospace applications has been introduced by Sperry Rand Corp.'s Vickers, Inc., Div.

Model PVB205 has a capacity of 50.2 gpm and output of 87.8 hp at its rated speed of 5,650 rpm and 3,000 psi. The compact unit has a maximum displacement of 2.05-cu.-in. per revolution. Rapid response permits changes from peak output to minimum flow in 0.05 second.

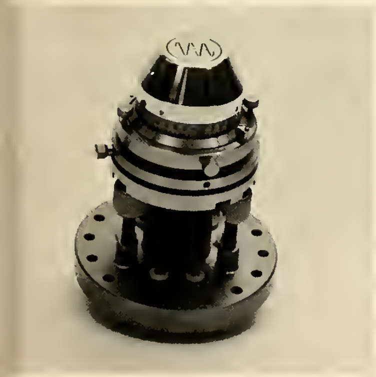
The unit has undergone military tests and exceeded all requirements after 1,000 hours of endurance testing, the firm says.

Circle No. 165 on Subscriber Service Card

Vacuum Feedthrough

An electromechanical vacuum feedthrough, used for moving and adjusting targets, sweeping with electrical probes, and actuating shutters and other mechanical devices, is being marketed by Varian's Vacuum Div.

Model 954-5031 rotates 360°, travels laterally in two axes and linearly in one, and tilts in any direction. It can be easily adjusted with great precision and locked in any position, the firm says.



Six ceramic-to-metal conductors are included for electrical penetration. The unit is rated to withstand temperature variations from −100° to 250°C.

Circle No. 166 on Subscriber Service Card

■ Pratt & Whitney Aircraft has openings in both Connecticut and Florida for qualified men who want to pit their knowledge and accumulated experience against a variety of complex heat transfer and compressor design problems. Positions are available at various levels, and we invite inquiries from the recent engineering graduate as well as from those with advanced degrees and considerable related experience.

heat transfer

■ Specific problems include analytical design and development evaluation of: Transient temperature analysis of complex gas turbine structures; High pressure cryogenic and storable fuel rocket engine systems: Convective heat transfer over a wide range of flow conditions; Analysis of engine lubrication and fuel systems involving conventional and high energy fuels; Compact heat exchanger design; Transpiration, film regenerative and ablative nozzle film, regenerative and ablative nozzle cooling; Turbine blade and vane cooling.

compressor design

■ Current problems include the design and development of supersonic airfoils, high-lift airfoils, extremely small gas turbines for space use and high Mach number, high pressure ratio turbofan stages. Other investigations involve research on unsteady aerodynamics in rotating machinery, aerodynamically excited vibration and boundary layer effects and control in rotating machinery.

■ These positions offer good salaries, early responsibility, an outstanding employee benefit program, and excellent opportunities for advancement. In addition, P&WA's plants in both Connecticut and Florida are located in areas that are ideal places for you to live and raise your family.

■ Depending on your geographic preference, send your complete resume, including salary requirements, to either Mr. P. F. Smith, East Hartford, Connecticut 06108, or J. F. Morton, West Palm Beach, Florida. We are an equal opportunity employer M & F.

Pratt & Whitney Aircraft

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DIVISION OF UNITED AIRCRAFT CORP.

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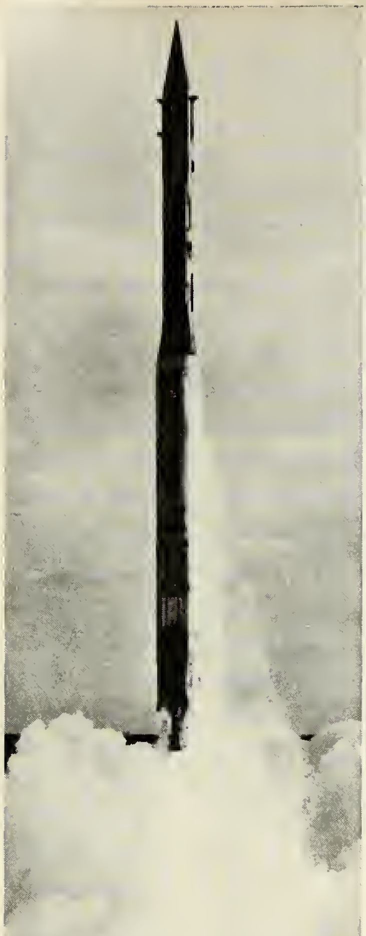

You'll never miss a missile when you jet National.

National Airlines offers you the only through jet service to all the space centers. Los Angeles, San Francisco, Houston, New Orleans and even to Melbourne—closest airport to the Cape. (Any closer and you'd be on the pad.)

Is this any way to run an airline? You bet it is.

Jet National.
Coast to coast to coast.

Circle No. 9 on Subscriber Service Card

Names in the News

WARD

McKENZIE

RICHARDS

BEST

Jerry D. Ward: Named vice president for marketing and advanced planning at North American Aviation's Los Angeles Div. He was formerly director of advanced planning and advanced program plans.

Reginald I. McKenzie: Elected executive vice president and treasurer of Aerojet-General Corp. He had been vice president and treasurer since 1962.

Dale J. Richards: Elected vice president of the Beryllium Corp. He will be responsible for domestic and international sales of the corporation.

Donald R. Best: Elected vice president and general manager of Gulton Industries' Gulton Industries (Canada) Ltd. The Canadian subsidiary is presently engaged in the engineering and production of a variety of products such as piezoelectric ceramic transducers.

Paul Hall: Named president of the Cooke Engineering Co. He has been executive vice president of the company for the past six years. Since last December, he has served as chief executive officer.

Dr. Walter Zaharevitz: Elected executive director of the National Aerospace Education Council. He retired from the Air Force as a major after 22 years of service.

Charles K. Mills: Named to the board of directors of Digital Development Corp. He is a corporation lawyer and former president of Textron Electronics, Inc.

Merritt A. Osborn: Named sales vice president of Milbar Corp. He will be responsible for developing sales of the company's line of hand tools.

John C. Reynolds: Elected a vice president of International Telephone and Telegraph World Communications, Inc. A former assistant vice president, he will continue to serve as executive assistant to the president and as director of management controls. He will also have functional responsibility for personnel, industrial relations and administration.

Howard J. Graninger: Appointed vice president of American Bosch Sales Div. of American Bosch Arma Corp. He was formerly associated with Cummins Engine Co.

Albert M. Currier, Jr.: Elected a vice president of Clevite Corp. He has been director of marketing for the company since 1963.

Clyde M. Bellinger: Named executive vice president of Kurz & Root Co. He will be responsible for the company's marketing and related activities and operate four plants for the company.

Emil J. Karkut: Elected as executive vice president of the Kaydon Engineering Corp. He will assist the president in the general management of the corporation.

Theodore A. Bruinsma: Joined the Packard Bell Electronics Corp. as executive vice president. Formerly, he was executive vice president of capital for Technical Industries, Inc.

Charles E. Krampf: Appointed executive vice president of Aerovox Corp. He has served as vice president, director and general manager of the company's Hi-Q Div. since Oct. 1949.

Donald B. McCulloch: Appointed vice president of marketing for Filtors, Inc., a manufacturer of hermetically sealed, high-reliability miniature and microminiature relays.

Robert J. Rodday: Elected vice president of the Brand-Rex Div. of American Enka Corp. He will continue as the division's general manager.

Dr. Wilmer L. Barrow: Selected to receive the Edison Medal from the Institute of Electrical and Electronics Engineers. He is vice president for research, development and engineering at Sperry Rand Corp.'s Sperry Gyroscope Co. Div.

Robert W. Sherman: Installed as president of the Society of Plastics Engineers for the coming year. He is with Union Carbide Corp.'s Chicago office.

William F. Hauser: Joined Sylvania Electric Products, Inc., as space communications systems analyst for Sylvania Electronic Systems. He will analyze the operation's technical and managerial activities and independent research and development programs in the space communications area.

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Annual Frequency Control Symposium, sponsored by the U.S. Army Electronics Command, Shelburne Hotel, Atlantic City, N.J., April 18-20.

Seventh Structures and Materials Conference, sponsored by the American Institute of Aeronautics and Astronautics, American Society of Mechanical Engineers, Cocoa Beach, Fla., April 18-20.

Spring Meeting of the International Scientific Radio Union and the Institute of Electrical and Electronics Engineers, National Academy of Sciences, Washington, D.C., April 18-21.

37th Annual Scientific Meeting of the Aerospace Medical Association, Dunes Hotel, Las Vegas, April 18-21.

Annual Engineering Conference and Tool Exposition, sponsored by the American Society of Tool & Manufacturing Engineers, Statler and Sheraton-Cadillac Hotels, Detroit, April 18-22.

Metals Engineering Conference, sponsored by the American Society of Mechanical Engineers, Sheraton-Cleveland, Cleveland, April 18-22.

National Association of Corrosion Engineers 22nd Annual Conference and Corrosion Show, Fontainebleau, Miami Beach, Fla., April 18-22.

Annual Meeting of American Geophysical Union, Sheraton-Park Hotel, Washington, D.C., April 19-22.

4th Annual National Conference of the Interservice Data Exchange Program, Waldorf-Astoria Hotel, New York City, April 20-22.

International Nonlinear Magnetics Conference (INTERMAG), sponsored by the Institute of Electrical and Electronics Engineers, Stuttgart, Germany, April 20-22.

Southwestern Institute of Electrical and Electronics Engineers Conference and Show, (SWIEEECO), Dallas Memorial Auditorium, Dallas, Tex., April 20-22.

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The Lessons of Vietnam—Part IV

SAIGON

TO FULLY ANALYZE the future potential of advanced technology in its application to tactical warfare, it is necessary to look at the political as well as the military implications of Vietnam. Is it an unusual situation or is it likely to occur again? Why are we there? Can we win such a war?

Let us first examine the five principal arguments of those who believe our engagement in Vietnam is a unique mistake which we should never repeat.

- Those who want to pull back from Southeast Asia behind a barrier of air and sea power tell us the U.S. cannot win a land war in Asia.
- They argue that South Vietnam is within China's "natural sphere of influence."
- They point to the instability of the Saigon government and the fact that the Viet Cong controls an asserted 80% of the land area of South Vietnam.
- They cite the desperate economic plight of South Vietnam.
- Above all, they contend that the majority of the people here want the war ended and would accept a Viet Cong government in order to achieve this. The U.S., they say, is not wanted here.

Before taking up these arguments one by one, it should be observed that an examination of the situation in South Korea at the time U.S. and Republic of Korea forces were driven back into the Pusan perimeter reveals a striking parallel on every one of these points. A study of South Korea and its economy today indicates what can be achieved, if the will exists to do it.

In reply to the specific arguments, these answers can be given:

- From the Boxer Rebellion through Korea, the U.S. has never lost a land war in Asia. In terrain very similar to Vietnam, American forces in the Philippines bested a Japanese army which excelled in jungle warfare. The U.S. then assisted the government in putting down a threatening Communist Huk rebellion which lost its strength in the face of superior force and an effective rural economic program. It is of interest that scattered Huk bands still are being hunted and killed in the Philippines today.

U.S. forces in South Vietnam are, in fact, already beginning to win the war here. It is quite conceivable, indeed probable, that this conflict can end as did similar insurgencies elsewhere—in the Philippines, Malaya, and Greece—not at the conference table but with a realization on the part of both the V.C. and the people that an insurgent victory is impossible. When that day arrives, the Viet Cong will disintegrate into unsupported bands with as much chance of victory as the scattered Huks of the Philippines.

- Far from being within China's natural sphere of influence, Vietnam has a history pockmarked with conflict with the Chinese. One might just as well argue that the U.S. should take over Mexico and Canada for the same reason.
- Of the instability of the South Vietnam government, there is little doubt. But the war is being successfully pursued despite that instability, even during the present crisis. The conditions necessary for stability can be established by military victory over the Viet Cong and, indeed, probably cannot be attained until such victory is won.
- There also is little doubt of the economic plight of inflation-plagued South Vietnam. But the U.S. has helped to rebuild shattered economies throughout Asia—in Japan, Korea, Taiwan, Okinawa, the Philippines. All of these countries now are prospering. There is no reason it cannot be done again.

The figure of 80% Viet Cong control, even if true, is a distortion. The bulk of South Vietnam's population and food supply (fish and rice) lies within areas controlled by the Saigon government.

- It is probably true that the majority of people in South Vietnam might vote for an end to the war even if it meant Viet Cong control. But if the U.S. is going to defend abroad its brand of democracy, it should pay some attention to just what it is that makes our Constitution different from, say, the Soviet Constitution.

The key to our form of government and way of life does not lie, as many believe, in the provision for majority rule. The Communists offer that. The true difference lies in our protection of the minority. That concept is alien to Communist ideology. Until there is some prospect of a government in Saigon which will provide such protection, we should remain. Most assuredly, a Viet Cong government, even if approved by a war-weary majority, does not meet the specifications. Our statesmen should talk less of majority rule and more of minority protection. If majority rule were a satisfactory criterion, United Nations forces could leave Cyprus tomorrow.

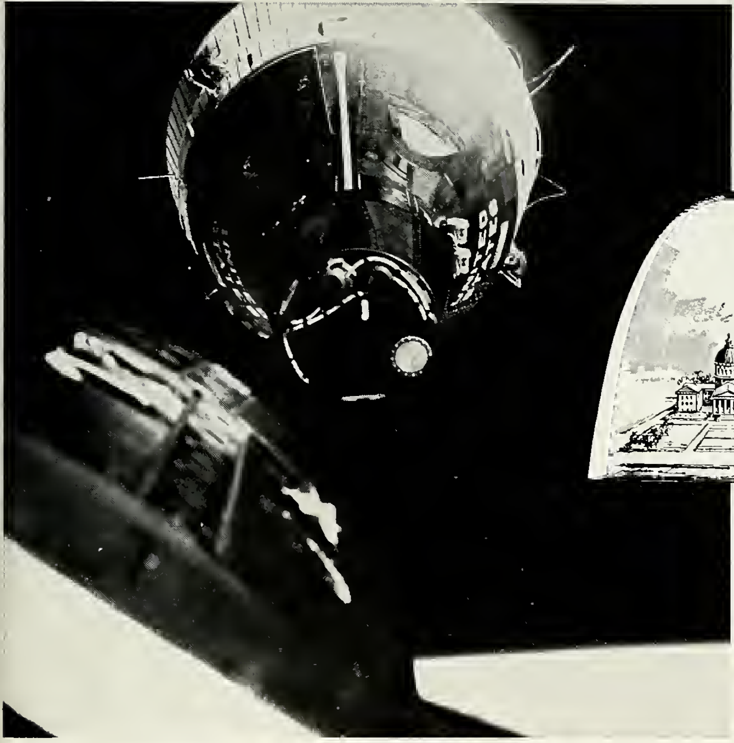
THE PROSPECTS OF SUCCESS of a policy of containment in Asia are as good today as they were in Europe 20 years ago. Many have forgotten how desperately close Fance and Italy came to Communism in the post-war period, or what the Marshall plan achieved in Europe.

The reverse of containment is the domino theory of toppling states. Without question, loss of South Vietnam would mean loss of Southeast Asia. But the implications are even wider. A demonstration in South Vietnam that an insurgency of this type can discourage or overcome the tactics and hardware of a powerful conventional force will set off explosive reactions not only in Asia but much closer to home in South America and elsewhere.

It is imperative that the U.S. develop and maintain a force capable of serving as a tactical deterrent just as effective as our strategic forces have been. Its first test is in South Vietnam, but the need for such a force, and its requirement for advanced technology, will exist throughout the foreseeable future.

(Last of a series)

William J. Coughlin



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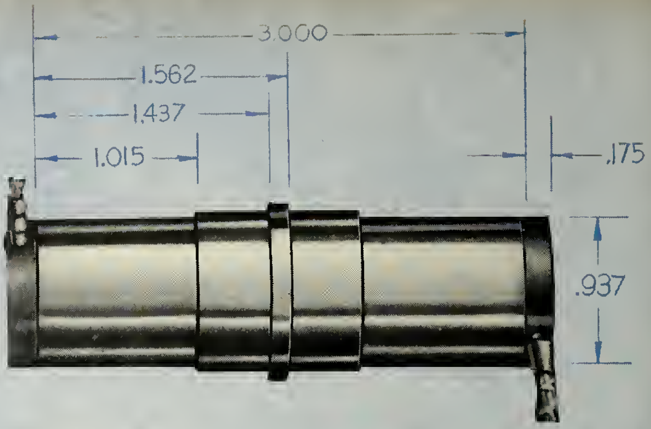
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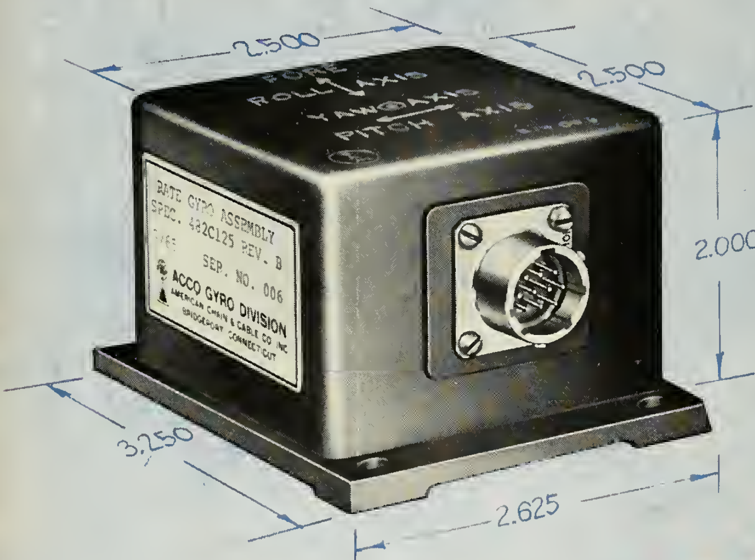
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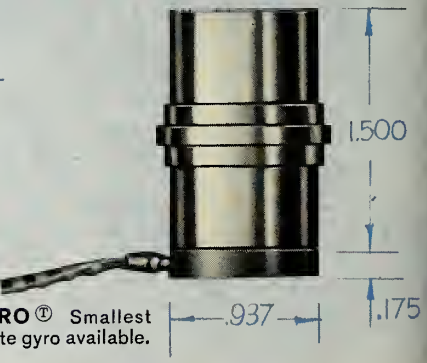
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missiles and rockets

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THE COVER

Modified Genie rocket is carried under wing of an Air Force F-4C over White Sands, N.M. Carrying scientific instruments in its detachable nose cone, the Genie was boosted to 150,000 ft. from the airborne launch platform and the nose cone was snatched at 5,000 ft. by an AF JC-130B (M/R, April 4, p. 8).

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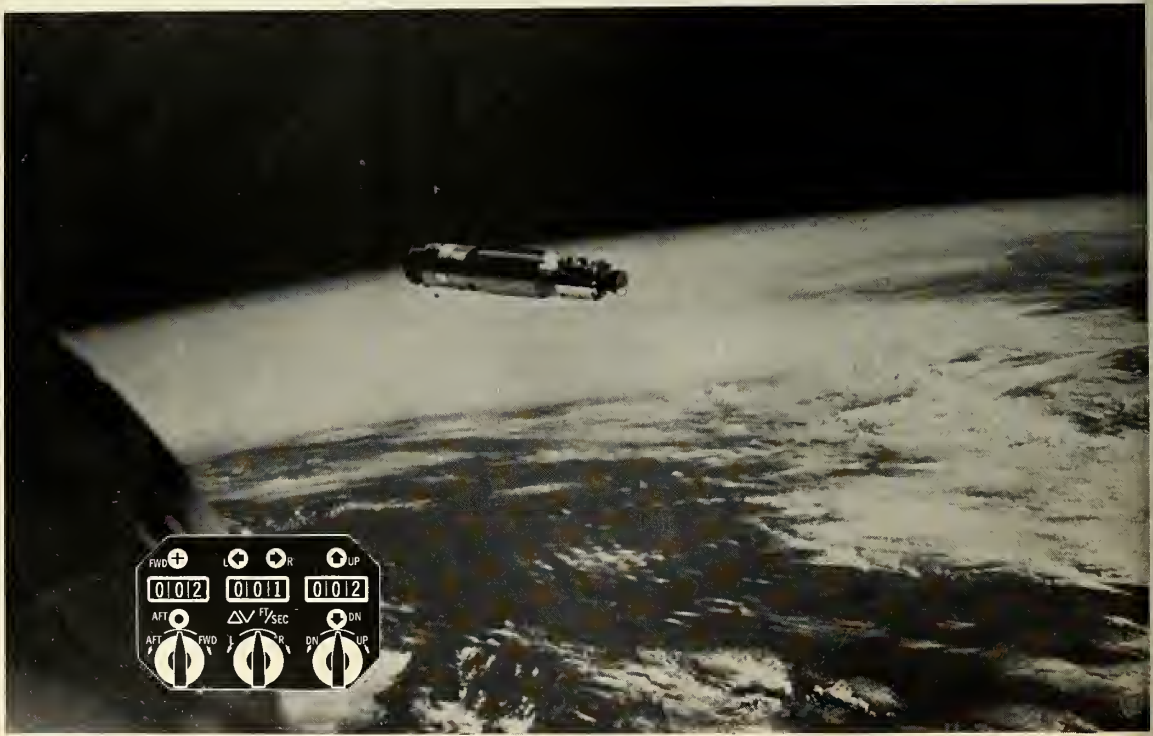

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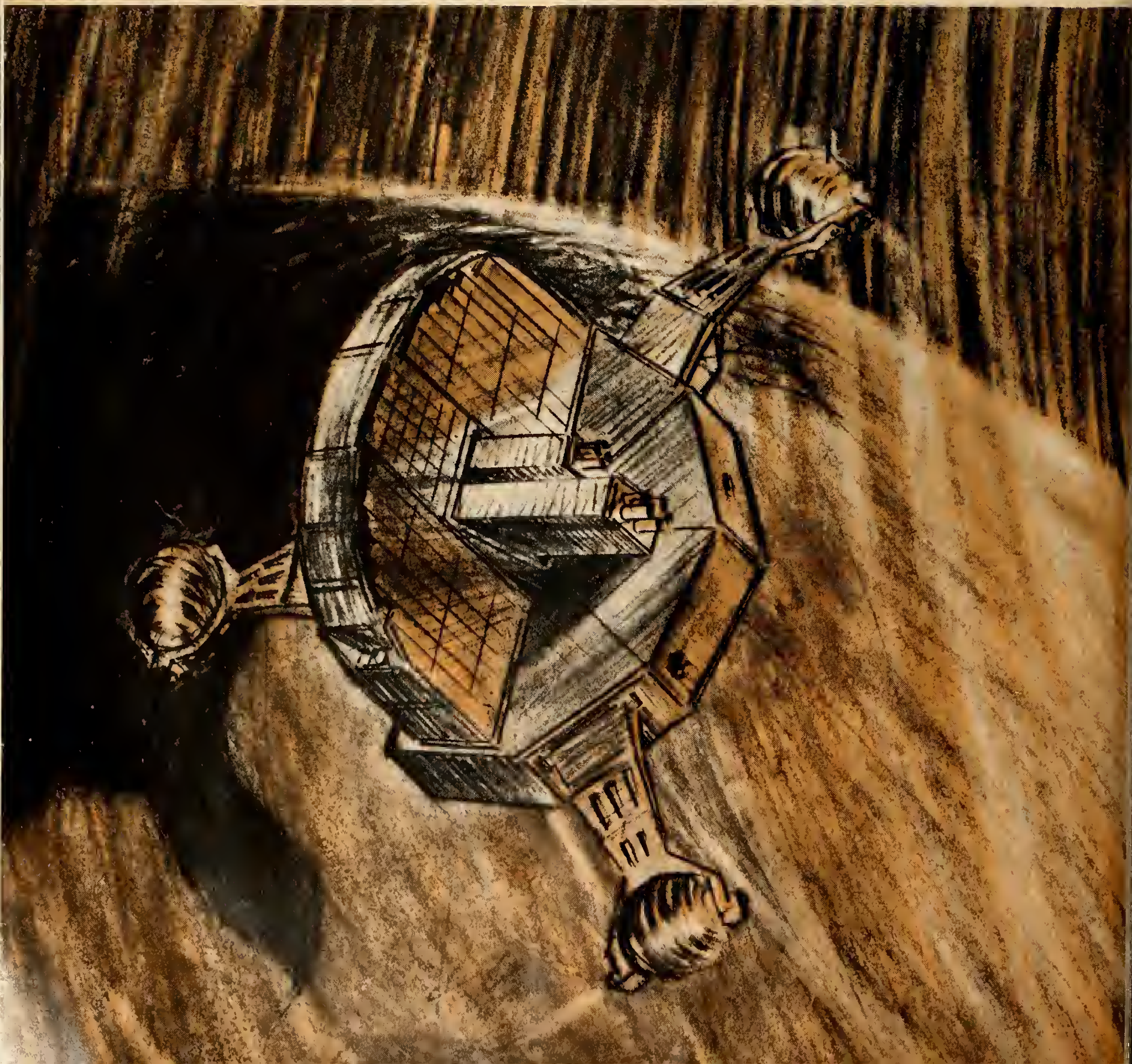
To transmit data from OSO-II's 8 experiments, EMR designed and built a 122-channel PCM system which operates on only 1.2 watts. Performance records show that not a single data channel was lost from the time OSO-II went into orbit February 3, 1965 until it was intentionally shut down more than nine months later.

The extensive experience gained on such systems as OSO has already been put to use in building the telemetry equipment of the future . . .



Letters

Annual DOD Issue

To the Editor:

I thought your Fifth Annual Department of Defense Issue was especially well done.

Certainly it is of value to me as our Defense Subcommittee of Senate Appropriations Committee gets its hearing schedule under way regarding defense needs for Fiscal Year 1967.

Warren G. Magnuson
United States Senate
Washington, D.C.

To the Editor:

. . . Most interesting and informative.

E. C. Gathings
Member of Congress
Washington, D.C.

To the Editor:

. . . A most excellent publication.

Joseph M. Montoya
United States Senate
Washington, D.C.

To the Editor:

. . . I am sure that the valuable information which it contains will make it a very useful source for reference.

Cornelius E. Gallagher
Member of Congress
Washington, D.C.

To the Editor:

. . . I am sure it will be a valuable reference source in answering the many questions received on defense, military and space matters.

John C. Mackie
Member of Congress
Washington, D.C.

To the Editor:

Your March 28 issue is outstanding. Congratulations on doing such a thorough job.

I believe that both the services and we in industry will be the better for reading this issue because it so well delineates the needs of the services and then tells us how to go about trying to fill these needs.

This issue should be "must" reading for any person dealing with the Department of Defense.

Peter Macdonald
General Manager
Washington Office
Goodyear Tire & Rubber Company
Washington, D.C.

To the Editor:

Congratulations on your outstanding Department of Defense issue. Your "Report from Vietnam" is one of the best advance planning documents for industry I have seen around in some time.

Dave Traitel
Electro-Optical Systems, Inc.
Pasadena, Calif.

To the Editor:

As a longtime reader of M/R, I have always enjoyed, and generally agreed with, your editorials.

With the March 28 feature on the lessons of Vietnam, however, you outdid yourself. I think you and Mike Getler have produced a really outstanding report on this much misunderstood military situation and I personally am most grateful to both of you for a job well done.

I believe it is unfortunate that this article can't be made required reading for every individual in this nation's defense industries as well as every lawmaker.

Louis P. Clark, Jr.
News Bureau Manager
Lockheed Propulsion Company
Redlands, Calif.

Visual Acuity Augmentation

To the Editor:

In your March 21 Technical Countdown column, a Space Medicine item noted completion of a new high-luminance vision laboratory at NASA's Ames Research Center. The necessary brevity did not permit description of research approaches, but the listed instruments and measurements indicate that path transmission effects are being emphasized. I would like to suggest that some effort be made to analyze the high-order augmentation of visual acuity coincident with chopped illumination. During the past five years I have scanned 15,000 titles on displays, read 250 abstracts on vision, and studied 15 reports on intermittent visibility without finding an explanation, or even a discussion, of vision enhancement by retina phase overlap.

My research was the result of personally experiencing the remarkable increase in vision on several occasions during airplane flights, with corroboration by others at the time. I have made some tests in my own shop leading to theory involving both foveal and chromatic factors. Since I am not qualified in the physiological aspects of the problem, I would like to propose that it be included in the program of the new vision laboratory as of general public benefit, with application to space vision. I am advising the Ames Research Center, by copy of this letter, of my suggestion for research on the temporal and chromatic factors of visual acuity augmentation.

E. J. Madden, ETOTD
Program Support Officer
ARSP/OV Satellite Programs
DoD Program Support Branch
Patrick AFB, Fla.

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The Countdown

WASHINGTON

How I Learned to Find the Bombs

To rebut criticism over bomb shortages in Vietnam, Dept. of Defense Secretary McNamara once more has delved into previously classified figures to get Congress and the press off his neck. The Secretary says the U.S. has 331,000 tons of bombs in the inventory, that production will hit 100% of the expected use rate by June and thereafter will exceed it. He says the U.S. is expected to drop 600,000 tons of bombs on Vietnam during 1966, 91% of the total dropped in 37 months of the Korean war. Nevertheless, DOD conceded last week that it has bought back for $21 each about 7,500 750-lb. bombs from a West German fertilizer manufacturer who bought them for $1.70 each.

S-II Stage Is Three Months Behind

Delivery of the S-II stage of the *Saturn V* booster now is three months behind schedule. It will not be delivered to the Mississippi Test Facility until June. Shipment to Cape Kennedy is scheduled for September—which should be in time for the official launch date in the first quarter of 1967.

Maverick RFP Expected Next Month

Requests for proposals on the Air Force's *Maverick* air-to-surface TV-guided missile system (M/R, Dec. 6, p. 14) are expected late next month, according to sources close to the project. Program now is undergoing final DDR&E review.

SAM-D Proposals Due in June

Proposals are due at Army Missile Command June 14 for contract-definition-phase effort on the *SAM-D* surface-to-air air defense missile system (M/R, Jan. 3, p. 12). Army Missile Command last week asked seven firms to submit proposals on a program which could run eventually to more than $2 billion. Firms are: RCA, Hughes, Raytheon, General Electric, Westinghouse, Boeing and Sperry Rand. Two or more contractors will be selected for the five-month CDP, with a single contractor picked for development and initial production.

Costs Outlined for S-IVB

Up to the end of Fiscal Year 1965, the S-IVB third stage for *Saturn V*—also used as the second stage of *Saturn IB*—cost a total of $359 million. Estimated costs in 1966 and 1967 are $233 million and $195 million. Unless further stages are ordered, this should close out the program.

AF Seeks New Minuteman Proposals

Air Force has asked three contractors—Aerojet-General, Thiokol Chemical and Hercules Powder—to submit proposals for a new third stage design for the *Minuteman III* ICBM. The new stage is described as considerably larger than the current missile stage. It is believed to involve a shift from the current four-nozzle design to a single nozzle. Proposals are due at Ballistic Systems Div. by May 23.

Delay Seen in Senate NASA Action

Senate Space Committee probably will postpone action on NASA's FY '67 budget until early May. Committee Chairman Clinton Anderson (D-N.M.) will attend the dedication of the 210-ft. antenna at Goldstone, Calif., late this month and then will return to New Mexico where he faces a May 3 primary election.

Navy ASW System To Get Test

Navy reports its newly established OMEGA VLF navigation system will get an intensive evaluation this year in connection with ASW exercises. OMEGA, a very-long-range system intended for use by ships, aircraft and submerged submarines, is dependent upon the propagation stability of the 10-14kc waves and precise atomic-clock frequency control.

INDUSTRY

Raytheon Steps Up Nike-X Work

An additional $20.6 million to Raytheon from Bell Telephone Laboratories for work on the Missile Site Radar for the *Nike-X* system brings total funding of the firm on MSR to more than $65 million. Raytheon also develops the transmitter amplifiers for the Multi-function Array Radar (MAR) of the anti-missile system and has received several million dollars in contracts on that effort.

Curtiss-Wright Gets Fluorine Award

NASA's Manned Spacecraft Center is financing development of 100-lb.-thrust pyrolytic graphite reaction control engines for use with fluorine fuels under a $305,000 contract with Curtiss-Wright Corp., Woodridge, N.J. The award was based on an unsolicited proposal. MSC is looking for 1,000 sec. total burn time on each engine with 500 sec. of steady space operation.

INTERNATIONAL

New Soviet Manned Flight Expected

Informed sources in Moscow say a flight that will take two or more cosmonauts farther into space than man has previously reached will come within the next few weeks. Duration is expected to be up to three weeks, which would top the 14-day orbital endurance record set by the U.S. Prediction of such a flight was made by the head of the Soviet Air Force, Marshal Konstantin Vershinin, on the fifth anniversary of the first manned space flight by Yuri Gagarin in 1961. He did not, however, set a date. Other sources said the flight was planned last month to coincide with the 23rd Communist Party Congress but was postponed. There has not been a manned Soviet space shot since March 18, 1965.

Castro Says Still Has Missiles

A West German magazine has quoted Cuban Premier Fidel Castro as saying he still has Russian missiles capable of reaching the U.S. mainland. Other than stating that these were smaller than the ones shipped back to Russia during the 1962 Cuban crisis, he gave no details. Washington officials discounted the report.

Vote Due on NASA Funding

The House Space Committee has sent the NASA Fiscal Year 1967 authorization bill to the floor of the House of Representatives for a vote on its passage.

The $4.986-billion bill is only about $25 million below the space agency's request. There was no estimate late last week when a vote by the House might be taken.

The committee vote on the bill was unanimous, but Rep. John Fulton (R-Pa.) filed a dissenting opinion calling for a reduction of $56 million in the Fiscal '67 request and another $10 million in previous authorization actions.

The $56 million would include $9.1 million for the lunar receiving laboratory, $41.9 million from the *Apollo* Applications Program and $5 million from advanced missions.

The reduction in previously approved authorizations would be taken out of facility planning and design funds. It was considered unlikely that Fulton would get much support on the House floor.

Saturn V Crawler Gets Well

MERRITT ISLAND, FLA.—"Testing on the first *Saturn V* crawler has been completed, and all redundant modes checked out. It will do anything we need now," according to D. D. Buchanan, chief of the launcher-transporter systems branch of NASA's Kennedy Space Center.

Only one change is in the works, he says, and this one is minor, to be installed between operations. It is an "autopilot" to keep the baseball field-sized top of the huge machine level within extremely close tolerances.

The autopilot will supplement the "tickle box" control which is now used for manual leveling. It will be switched on after the manual control is used for loading the huge rocket and its service tower, and monitor and control the vehicle's leveling during the several-hour trip from the Vehicle Assembly Building (VAB) to the launch pad.

When the entire vehicle-load combination arrives at the launch site, the operator will again take over for the setting down of the *Saturn* and its tower.

NASA, General Electric and Bendix are working as a team on the design of the autopilot unit, which, Buchanan says, will be made of largely off-the-shelf components. The finished product, he says, will be simple enough to make so that one of the local support shops—probably Bendix—will put it together.

The launcher-transporter chief says the new unit will probably be installed and working by summer. It will be installed between operations, such as the movement of the full-scale mockup of the *Saturn V* now in the VAB to the launch area.

Navy Tests Aircraft Navsat

The first aircraft satellite navigation system has been flight-tested for the Navy by engineers from Honeywell, Inc., and Johns Hopkins University.

The system, consisting of a Honeywell H-386 inertial navigator coupled to a Navy satellite receiver, was flown in a P3A Orion aircraft at the Naval Air Test Center, Patuxent River, Md.

The test proved the system can provide global, all-weather, all-altitude navigation with position accuracy measured within 0.5 mi., the engineers said.

Shots of the Week

The Soviet Union launched the *Cosmos 115* scientific satellite April 20, Tass has announced. The spacecraft was placed in an 89.3-minute orbit with an apogee of 184.5 mi. and a perigee of 117.9 mi. Inclination is 65 degrees.

- The Strategic Air Command successfully fired a *Titan II* ICBM from Vandenberg AFB, Calif., on April 20.
- A *Polaris A-3* missile was launched from the USS George Washington on April 14, 2,500 mi. downrange from Cape Kennedy.

AF/Army Define Aircraft Roles

The Army and the Air Force have reached a joint decision on responsibilities for control and deployment of certain types of fixed- and rotary-wing aircraft.

Under an agreement recently announced, the Army will transfer its CV-2 (Caribou) and CV-7 (Buffalo) aircraft to the Air Force, which will be responsible for all future intra-theater fixed-wing tactical airlift.

The Army will be responsible for all rotary-wing support for intra-theater movement, fire support, supply and resupply of Army forces and Air Force elements working with the Army to coordinate air support. The Air Force will retain responsibility for rotary-wing aircraft involved in Air Force search and rescue and special air warfare missions and administrative support missions.

The two services will continue to consult on design of follow-on fixed-wing aircraft and will continue joint development of VTOL aircraft.

Geophysics Meet Draws 2,300

Space sciences played a more prominent part than ever before in the annual meeting of the American Geophysical Union, April 19-22 in Washington, D.C.

Speakers delivered more than 700 technical papers in eight subdivision areas of geophysics including meteorology, oceanography and planetary sciences. More than 2,300 engineers and scientists registered for the meetings.

Results of an Arthur D. Little, Inc., study indicated that "spacecraft instrumented for sensing into the far infrared would be able to provide more information about the composition of planetary surfaces than vehicles with conventional infrared capability."

The author of this study, Dr. James R. Aronson, said the primary value of the longer wavelengths is their ability to provide more information where more information is needed, as with complex mixtures of materials.

For his work, supported by Marshall Space Flight Center, he took far-infrared spectra of a number of possible lunar and planetary surface materials including plagioclase feldspars, pyroxenes, olivines and quartz, and "rules were developed for unscrambling the spectra of complex composites."

An important finding was that meaningful data can be obtained even from surfaces consisting of fine particles.

In another paper, Dr. Alfred J. Zmuda of the Johns Hopkins University's Applied Physics Laboratory said, "there are likely to be a dozen points over the South Atlantic Ocean where the electrons of the Earth's radiation belts spill into the atmosphere producing areas of high-intensity ionization and sapping the contents of the Van Allen and the artificial radiation belts." He noted that these areas of enhanced ionization may exist in the lower atmosphere, 50 to 80 miles above Earth.

A speaker presented new evidence that organic compounds found in meteorites are not signs that life exists on other worlds. Experiments showing that the compounds "could easily have been formed without the aid of living organisms under conditions that existed during the early history of the solar system" were described by Edward Anders, professor of chemistry, University of Chicago.

OV3-1 Launch Delayed

First launch of *Orbiting Vehicle 3 (OV3-1)* was tentatively set for April 21 at the earliest from Vandenberg AFB, Calif.

The launch, originally set for April 19, was scrubbed when what appeared to be a fault in the launch vehicle's guidance system was detected. This was later found to be a false signal generated in the ground support equipment.

The satellite and its *Scout* booster was reported ready for launch as soon as it could be scheduled by the Western Test Range. The vehicle is being launched by the 6959th Aerospace Test Wing.

South America Comsats Studied

Page Communications Engineers, Inc., will conduct a seven-month feasibility study of the use of satellite communications in South America.

The $250,000 contract was awarded by the Inter-American Development Bank. Page will explore the advantages of satellite communications over conventional methods for the entire South American continent. It will also help determine the most economic locations for Earth stations to link South America to the global satellite communications network.

Nimbus C Launch Set

The *Nimbus C* spacecraft is scheduled for launch from Cape Kennedy no earlier than April 29.

The 912-lb. spacecraft will be labeled *Nimbus II* if it successfully achieves orbit. *Nimbus C* will provide instantaneous, around-the-clock weather photographs from space using its automatic picture transmission (APT) system.

The spacecraft will be placed in a circular orbit of 690 statute mi. by a thrust-augmented *Thor-Agena B.*

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Changes in Store for AF Non-Profits

by Michael Getler

WASHINGTON—A detailed review of Air Force relations with its three major not-for-profit supporting organizations has affirmed the service's continuing need for two of these corporations—and recommended operational changes which may both limit their growth and expand their usefulness.

The report on the organizations—Aerospace Corp., Mitre Corp. and Systems Development Corp. (SDC)—was prepared by the Air Force Systems Command's Board of Visitors' *ad hoc* group. The review was ordered last August (M/R, Sept. 6, p. 11) by AFSC chief General Bernard A. Schriever after a House Armed Services Special Investigations Subcommittee had publicly blasted Aerospace Corp. and the Air Force (M/R, Aug. 23, p. 14) for a string of policy violations and mismanagement charges.

The *ad hoc* group's report was completed last December; however, it was not publicly released until last week together with comments by both Schriever and Air Force Secretary Dr. Harold Brown.

The recommendations of the board essentially support many of those made by the Congressional committee headed by Rep. Porter Hardy (D.-Va.) last year. A spokesman for the committee told MISSILES AND ROCKETS they were "pleased" with the report and found its objectivity "refreshing."

Findings—Major recommendations of the *ad hoc* group include:

—Air Force relationships with SDC should now be placed on a normal service/contractor basis, a move favored by the company.

Citing the excellent past record of SDC in performing virtually all of the computer programming for the Air Defense Command, the board pointed out that the time was now ripe for this to be taken over by in-house commands. At the same time, it noted the spread of software technology throughout industry. New Air Force out-of-house business in this area, including some ADC support, will now be competitive.

—The continued use of annual contractual ceilings for Mitre and Aerospace appears to be the best way to apply a forcing restriction for selective assignment of programs to these organizations. Aerospace Corp. has had an annual volume of business between $75-$80 million for the past three years. Mitre's annual operating level is now about $36 million.

The contractual ceilings are intimately tied to the question of the size of the corporations, a question which is of most concern regarding maintenance of the technical superiority of the non-profits.

The report cautions the Air Force against any increase in size, and suggests that they study "the possibility of making modest reductions that would upgrade the overall quality by decreasing the quantity." Schriever added that he did not expect the professional staffs to grow "unless unforseen program needs demand it."

The board notes that while Mitre's staff size is not out of line, and is "competent," the Massachusetts-based corporation has "set its standards too low and should take steps to upgrade its quality."

"Aerospace, on the other hand," the report states, "has done an excellent job of recruiting a top-flight professional team. Nevertheless, it has grown to a point of general concern. There is a consensus that Aerospace is too large and could probably be a more effective organization if it were smaller."

The board, however, admitted that current use of the firm was appropriate and that there were now no apparent specific areas which could be reduced significantly without jeopardizing important on-going missile/space programs.

The feeling in general was that once a technical staff approaches the 2,000-individual level, as Aerospace has, "it is no longer possible for management to assure maintenance of its elite characteristics."

In favoring the contractual ceilings, the board notes that these "will be somewhat arbitrary." However, it added, it will lead to "organizations sized so that there are jobs which could be assigned, but because of the limited availability of resources and lower priority, they are done elsewhere."

—The *ad hoc* group also recommended that the Air Force and the non-profits "work towards a minimum-fee position"—developing practices which would allow reimbursement under the Armed Services Procurement Regulations (ASPR) for the majority of expenses now being expended out of fee. "Under such a practice, facilities, research, salaries, and consultant fees should be limited to expenses which can be appropriately recognized and reimbursed as costs under the contract."

AF accord—Secretary Brown concurred in working toward this and away from the current "needs" formula, which relates fee to specific corporate requirements. Brown said the weighted guidelines of ASPR should be tried out as a general framework for fee negotiations, adjusted accordingly and considering certain tax differentials pointed out by the Congressional committee.

Brown feels that the adjusted guidelines should lead to "a fee substantially lower than at present." Current fees are believed to be on the order of 5-6%.

—The report also recommended that the Air Force request new funds to pay off the mortagages and clear the titles to existing corporate facilities, a proposal turned down by both Shriever and Brown. Shriever said the corporations should own their existing facilities "because ownership assures complete operational control and a desirable degree of stability."

The report also recommended that new facilities be bought by the Government.

Both Brown and Schriever did go along with a recommendation that contractual clauses be inserted which preclude disposal of facilities by the non-profits without Air Force approval.

—A board recommendation that a top-level Air Force policy group be set up within the Secretary's office as a focal point to deal with the corporations on administrative and fiscal matters was tempered somewhat by Schriever and then turned down by Brown.

Brown added, however, that the officers mentioned would of course be available as policy questions arise.

Schriever pointed out than any infringement on the fundamental corporate responsibilities of the respective boards of trustees by the Government "tends to destroy the essential independence of these organizations and thus precludes their serving the Air Force effectively."

Brown and Schriver both emphasized throughout their comments on the report the necessity of vigorously holding the boards to all management responsibilities, and improving the communications between these boards and the Air Force divisions they support.

Misunderstandings—There is still a serious communications gap between Aerospace and the Air Force on the management and business side of the relationship, according to the report. Whatever the reasons for this gap, "it must be mended by both sides if it is not to result in a total deterioration of the total relationship."

The Air Force must be aware, the board cautions, that its responsibilities do not include interference with corporate internal management, and the corporation must recognize that it is and must be subject to public and Air Force scrutiny since in the final analysis "the

Air Force must defend its use of these corporations, their accomplishments, and validity of their costs."

In contrast to the Aerospace/SSD communications problems, communication and dispute settlement between Mitre and ESD has been good, the report finds.

It also finds that Mitre has other problems, stemming from a less aggressive posture than has been taken by Aerospace in its role as general systems engineering/technical director. "Mitre tends to consider itself ESD's principal technical advisor . . . and while it has developed a sense of technical independence, it does not have the enthusiastic willingness to accept its GSE/TD responsibility in all its implications."

—In another major recommendation, the report made note of the serious implication for the Air Force/non-profit relationship raised by recent public scrutiny and criticism.

"The resulting uncertainties about the future of these companies," according to the report, "have damaged morale and have an adverse effect upon their ability to recruit and retain good people.

"The Air Force has an urgent requirement for the superior professional services of these corporations on programs of national significance [a point stressed throughout the report in addition to consistent commendations for the work performed]. If doubt concerning the validity of the need and importance of these corporations is not removed, the ability of the Air Force to accomplish its mission in space, ballistic missiles, and electronics could be seriously impaired.

"The group believes it is important for the Secretary of Defense and the Secretary of the Air Force to reaffirm the importance of the role of both Aerospace and Mitre Corps. in the nation's vital security."

The board also pointed out that this relationship between the national need and the performance of these corporations will continue to change. It recommended that the situation be re-examined every three to five years.

Members of the *ad hoc* group were Dean Howard W. Johnson (cochairman), Alfred P. Sloan School of Management, Massachusetts Institute of Technology; Maj. Gen. John W. O'Neill (cochairman), commander, Electronic Systems Division, Air Force Systems Command; Charles A. Anderson, president, Walker Mfg. Co.; Dr. William O. Baker, vice president-research, Bell Telephone Laboratories, Inc.; Lyle S. Garlock, vice president, Eastern Airlines, Inc.; Thomas V. Jones, president, Northrop Corp.; James R. Kerr, president, Avco Corp.; Gen. Nathan F. Twining (USAF, retired).

Response—Commenting on what he called an "in-depth study" by the board, Aerospace President Dr. Ivan A. Getting said the report "will do much to make even more effective the relationship between our company and the Air Force."

Another Aerospace spokesman told M/R that "there is no fundamental disagreement with the recommendations. However," he added, "while the recommendation that the fees paid should be more closely scrutinized cannot be disagreed with, the specific steps taken to implement this will inevitably be a subject for discussion and argument."

A spokesman for SDC told M/R that the firm was gratified at the formal Air Force recognition of SDC's status as an independent non-profit organization, no longer to be governed by the rules the Air Force continues to apply to Aerospace and Mitre, with which it maintains a very special kind of relationship.

SDC will not now become a profit-seeking firm, but will continue to serve as an independent non-profit organization much in the same fashion as the Stanford Research Institute and the Battelle Memorial Institute, for example. It will compete for contracts and be treated as an industry contractor. The firm, however, does not expect too rapid a drop in Air Force-contracted work, which now accounts for about 82% of SDC's business. ■

Preliminary Navy Testing Uncovers OV-10A Flaws

WASHINGTON—A preliminary Navy evaluation of the OV-10A counterinsurgency (COIN) aircraft (M/R, Mar. 28, p. 56) has reportedly turned up 31 mandatory changes necessary in the aircraft, six of which are regarded as very serious.

Included in the latter category are charges that the aircraft is about 40 knots under its 265-kt. speed guarantee and has a single-engine ceiling 10,000 ft. short of specifications.

Also judged as serious failings in its current design by the evaluation team are: unsatisfactory longitudinal control, which will require a change in the horizontal stabilizer; excessively high single-engine control speed, coupled with a high aircraft roll rate in the event of engine failure at low speeds; insufficient acceleration abilities; high vibration in the vertical plane; and an unduly complex power-management operation.

It was also stated that the OV-10A cannot climb on one engine with the landing gear down, that the takeoff roll is excessive, and that as a result of contractor deficiencies and approved design changes the aircraft was now 300 lbs. overweight.

Sources close to the project say that a second preliminary evaluation of the North American Aviation craft will be held in July, and that the following board of inspection and survey (BIS) trials would not get under way before September.

Among the other items requiring mandatory changes were problems related to the plane's ability to taxi, gear locking mechanisms, watertight integrity of the cockpit, inability to reach emergency stores without the pilot unfastening shoulder harnesses, and the need for improved visual approach instrumentation.

In addition to items requiring mandatory changes, the Navy also reportedly listed 135 other changes as "desirable."

Despite the list of shortcomings, Navy project sources told MISSILES AND ROCKETS that the service had reviewed the contractor's plans for remedying the faults, has approved them, and feels that the contractor is capable of turning out an aircraft that will be satisfactory for service use.

The only area in which Navy sources feel the final aircraft may fall short is in reaching the advertised maximum speed. "It is a little draggier than we expected," they comment.

The Navy also reports that no slippage is anticipated in the OV-10A delivery date, slated for May, 1967.

Navy sources also report that the OV-10A was put through 78 hours of flight testing during this first Navy Preliminary Evaluation (NPE), far more than is normal. The aircraft was also flown by Air Force and Marine aviators, with Army pilots also monitoring the tests. "The NPE is not designed to find the good points of any aircraft," they stress.

NASA Ponders Apollo Team Future

by Hal Taylor

WASHINGTON—NASA has established a special group to determine when Project *Apollo* production will end and when new programs will have to be initiated in order to maintain the space capability of the lunar-landing program's contracting team.

The problem is becoming critical. For example, the last third stage for the *Saturn IB* will start down the manufacturing lines at Douglas Aircraft Co. next month. The last S-IVB third stage for the *Saturn V* will enter the production line in October, 1966.

The problem is also difficult for Chrysler Corp., prime contractor for the *Saturn IB* first stage, which will start to run out of work when the last booster enters production in October.

Establishment of the special group was disclosed in the printed account of the hearings held by the House Space Committee on the agency's Fiscal Year 1967 budget. Some of the hearings were held by the Committee at Project *Apollo* contractor installations.

During a visit to Douglas, Congressmen expressed surprise at the nearness of the end of *Saturn IB* production. The same situation will confront all of the other contractors in about a year.

Bind approaches—Donald Douglas, president of the firm, told the Congressmen that he had discussed the problem with Dr. George E. Mueller, NASA associate administrator for manned spaceflight, and the *Apollo* executive council.

"It is getting to be a very tight thing if we don't have a follow-on program," Douglas said.

Capt. Robert Freitag, director of Manned Spaceflight Field Center Development, told the Congressmen that "We are carefully looking at the entire program. We want to be prepared to present to your committee next year exactly what is happening in the program. We've talked it over with the presidents of the *Saturn/Apollo* contracting companies—particularly with Tom Morrow, the vice president of Chrysler Space Div., because his is the first program to have a production falloff."

"NASA, through Headquarters, is conducting a special study, there's a team out right now and that team has already been here to Douglas, to determine all aspects of the program," Freitag continued.

Earlier, the committee was also briefed on some of the problems and achievements of the project by members of the contracting team.

These included:

—North American Aviation, Inc. expects to receive a new contract this summer for five more S-II stages. The new award will bring the total in the program to 15. It is expected to be a cost-plus-incentive-fee award.

—The main remaining problem in development of the Lunar Excursion Module seems to be some combustion roughness in its descent engine when it is in the mid-throttle range of operation.

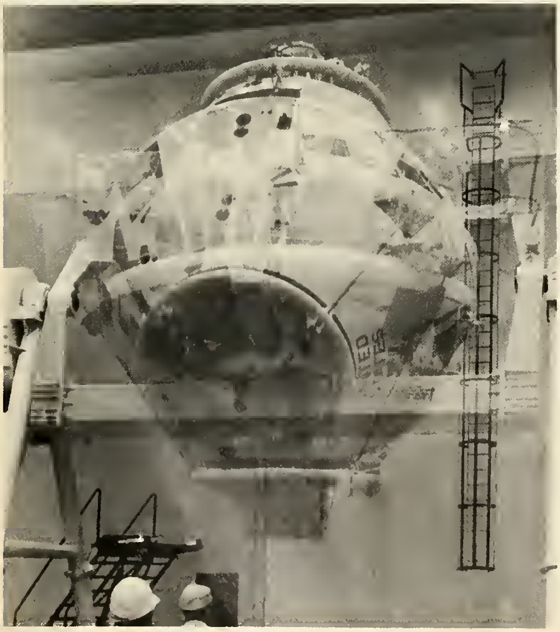
Craft arrive—Meanwhile, two *Apollo* spacecraft—one scheduled to be the second unmanned *Apollo* to be launched into space—have been delivered to Manned Spacecraft Center.

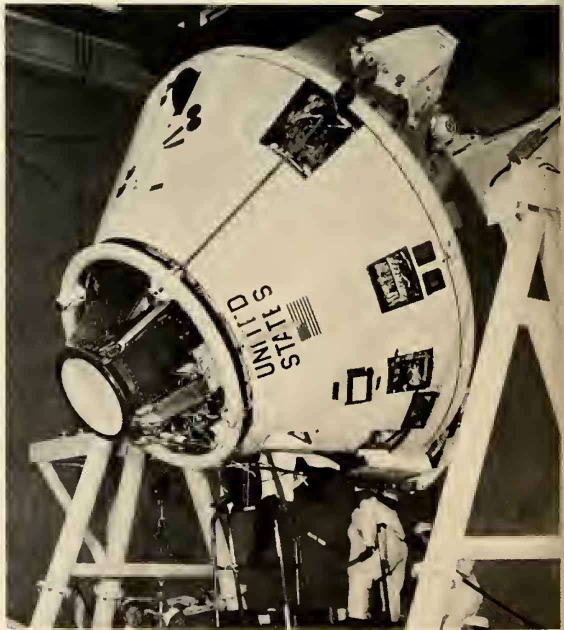
The vehicles, identified as spacecraft *011* and *007*, were produced at the Downey, Calif., plant of prime contractor North American Aviation, Inc.

Spacecraft *007* will be used for water impact and floatation tests in the Gulf of Mexico and in an environmental tank at MSC. These will be the final *Apollo* water-landing tests.

Spacecraft *011* has a Command Module similar to those which astronauts will man in later flights and a Service Module which contains support systems including environmental control, fuel cells and the main spacecraft propulsion system.

The primary goal of its mission is to gather additional data on the *Apollo* heat shield to supplement that obtained during the Feb. 26 unmanned flight of the *Apollo 009* spacecraft. ■





Apollo spacecraft Command Module 011 receives final tumbling test in world's largest clean room at North American Aviation's Space and Information Systems Div., Downey, Calif. Test was part of final inspection procedure of structure before it was shipped to Cape Kennedy. Spacecraft 011 is due to be launched unmanned during the third quarter of this year.

S-IVB Stage May Become Space Station

by Jinx Mercer

HOUSTON—The Manned Spacecraft Center has taken the first step leading to use of a spent S-IVB rocket stage as a 30-day space station.

The plan calls for placing the stage in orbit with a *Saturn IB* launch vehicle. Later, manned *Apollo* Command and Service Modules would rendezvous with the stage for extended flights of up to 30 days.

In another manned space flight action, the center announced that the upcoming *Gemini 9* flight would be launched no earlier than May 17. The flight plan for the mission calls for performing many of the space maneuvers which had to be dropped when the *Gemini 8* mission was terminated early on March 16.

The use of the S-IVB as a space station will require an experiment module to enable astronauts to live in the spent stage.

MSC awarded separate, fixed-price ($50,000) definition study contracts to the McDonnell Aircraft Corp., Douglas Aircraft Co. and Grumman Aircraft Engineering Corp. on April 18 to define, design and evaluate a plan to convert the hydrogen tank of the *Saturn* stage into laboratory space during extended-duration *Apollo* missions. The three contracts cover a 60-day period.

Airlock connection—The experiment, which is managed by NASA's Marshall Space Flight Center, makes MSC responsible for an interconnecting airlock/tunnel that would link the Command Module to the *Saturn* upper stage's hydrogen tank.

Kenneth S. Kleinknecht, deputy manager of the *Gemini* program office, said the Spent Stage Experiment Support Module (SSESM) would be mounted within the Lunar Excursion Module adapter section on "hard points" designed to hold the LEM. One end of the airlock would have a docking ring to which the apex section of the Command Module would dock; the other end of the airlock would have an exit port to mate with the "manhole cover" of S-IVB hydrogen tank.

"The airlock would not be attached to the S-IVB, at launch," Kleinknecht said. "As part of the experiment, the astronaut would remove the manhole cover, connect a flexible boot of some type, and pressurize the experiment support module to 100% 5-psi oxygen atmosphere." The SSESM would be equipped for pressurization and for extending life-support and electrical power from the C/SM to a converted laboratory section. The hydrogen tank, which is 21.7 ft. in diameter and approximately 20 ft. long, would hold a variety of experiments and "probably a large hatch" for conducting extra-vehicular experiments.

Apollo spacecraft-qualified equipment would be used, he said, to maintain astronauts in orbit from a minimum 14 days up through 30 days.

Only one SSESM will be purchased by MSC for the Marshall experiment, he said, "The contract, however, will give us legal option to buy up to three more."

Delivery of the support module is scheduled for sometime in 1968 at the earliest.

GTA-9 goals—Plans for the three-day *Gemini 9* mission now scheduled to begin May 17 will include three rendezvous and docking exercises, several "minimum impulse" burns by the *Agena* primary propulsion systems while the two vehicles are docked, and extravehicular activities lasting one and one half orbits.

Astronauts Thomas P. Stafford and Eugene A. Cernan will first rendezvous with the *Agena* target at third spacecraft apogee and move in for docking a short while later. Two "re-rendezvous" exercises—a passive target rendezvous and a lunar-abort trajectory procedure (M/R, April 18, p. 15) —are scheduled for the third day.

Extravehicular activity will begin on the second day in August and merely duplicate the procedure originally outlined for the *Gemini 8* mission:

Cernan will climb out of the spacecraft, retrieve a nuclear emulsion experiment plate from the adapter, activate a micrometeorite collection devise (for retrieval by a *Gemini* pilot on a later mission) on the *Agena,* and operate a minimum-reaction space tool. He will also evaluate the 25-ft. umbilical for tether dynamics.

Prior to entering the night-side of the orbit, Cernan will climb into the spacecraft adapter to check out and don the Air Forces Astronaut Maneuvering Unit (AMU). Stafford will undock from the *Agena* and move to the station-keeping position 100-125 ft. away.

Cernan will emerge on the second day-side, move to position in front of the spacecraft and begin orbital evaluation of the rocket backpack gradually extending his tether length to the full 115 ft. The crew will also simulate orbital pickup of a "passive" astronaut—an abort flash-rescue procedure for the Lunar Excursion Module pilot in the event the lunar vehicles fails to hook-up in lunar orbit.

Sometime during the third day, Stafford will light up the *Agena* PPS for the first of three maneuvers while the two vehicles are docked. The flight plan calls for a "small" maneuver out-of-plane and posigrade and retrograde maneuvers in-plane.

Retro-fire is planned for approximately 70 hrs. elapsed ground time. ■

Astronaut Eugene A. Cernan shown performing "preview" flight in spaceflight simulator at LTV Aerospace Corp., Dallas, using Astronaut Maneuvering Unit (AMU) developed by that firm. Cernan is scheduled to take a space walk with the back pack during the Gemini 9 mission next month.

Sparse Oceanology Funding Criticized

by Robert W. Niblock

WASHINGTON—Rep. Paul Rogers (D-Fla.) has scored the Defense Department for not providing the Navy sufficient funds for undersea technology.

His criticism came in two speeches delivered last week on the floor of the House of Representatives.

A member of the oceanographic subcommittee of the House Merchant Marine and Fisheries Committee, Rogers has long advocated increased Federal outlays for ocean research and ocean engineering.

He said April 18 that the lessons learned during the 80-day search and recovery operation for the H-bomb lost off Palomares, Spain, should not be forgotten—and that the U.S. "cannot afford to again economize, to again be penny-pinching in an area so important to our future military and economic posture."

Two days later he said "the H-bomb recovery shows that the Navy was doing a space-age job with stone-age tools. In less than 10 years, outer space exploration has produced space vehicles which know no horizon. However, the Navy does not yet produce deep-diving vehicles of the same degree of sophistication found in the space program's vehicles."

During the first talk, in which Rogers provided complete details on the search, he urged Congressional committees "most intimately concerned with deep-ocean technology and military preparedness" to begin immediate public hearings on the "state of deep submergence in the United States."

Noting that industry would provide the future leadership and know-how for ocean exploration, Rogers said he was sure it would welcome a proposal for open hearings.

Rogers laid the responsibility on the Congress for reminding the "accountants and tradition-bound admirals of the Defense Department of the urgency for immediate action, and of the pressing need to re-examine the inadequate budgets which have been approved for this important but lagging endeavor in the forthcoming fiscal year."

He said that if the recent multi-million-dollar H-bomb search is any indication of the consequences of inaction, the budget (now about $229 million) for the Navy's Deep Submergence Systems Project (DSSP) should be doubled.

Rogers, as many others, talks of the direct "spinoff" to industry of technology developed for DSSP. "I strongly believe," he said, "we should keep clearly in mind that any additional support we can give the Navy in the form of supplemental appropriations for accelerating the deep submergence project, and for expanding its now limited objectives, will provide the technology which eventually will also be needed for commercial exploitation of the ocean."

Rogers admitted that the Navy was in better shape for the H-bomb search than it was for the Thresher disaster, having two deep-diving submersibles—the Woods Hole Oceanographic Institution's Alvin and Reynolds International Corp.'s Aluminaut—available for the operation. Also available was the Perry-Ocean Systems, Inc. Cubmarine and the Navy's Deep Jeep.

There were three main problems, according to Rogers, facing the Navy at the outset of the H-bomb search, and these, he added, were the same that confronted the Thresher's searchers.

First problem cited was a "very sketchy knowledge of the topography of the sea bottom in the search area, and only the most rudimentary methods of underwater navigation." Bottom ruggedness, including granite outcrops, and a thick covering of fine, silt-like ooze added to the complications. The ooze was stirred up by the submersibles' propellers, creating clouds of silt that often slowed the visual search with lights.

The lack of sophisticated tools and instruments for deep-water search was again a problem, despite the fact that the required capabilities for such tools were spelled out after the Thresher search. The magnetometer, often used for metal object searches, was of no value since none of the components of the weapon was sufficiently magnetic.

The third and perhaps the greatest obstacle, said Rogers, was the weather on the scene, "which frequently frustrated the efforts of the searchers."

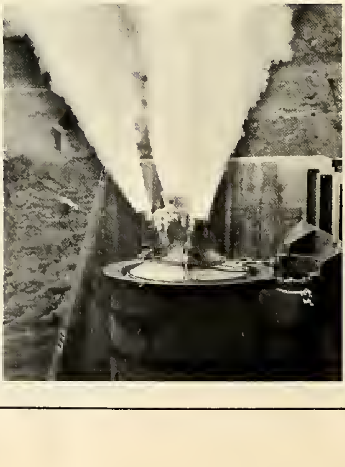
The searchers aboard the submersibles gained valuable experience, said Rogers, and "they found the only reliable instrument for search in the depths was what they referred to as the 'Mark I eyeball': the human eye."

Alvin, which alone made a total of 145 dives, "was cautiously backing down a 70-degree slope—her observers being unable to look over the nose of the Alvin at this angle—when the bomb's parachute was spotted" March 15 at a depth of 2,532 ft.

"The bomb," said Rogers, "weighed eight tons, but Alvin was able to lift only 20 lbs. with its mechanical arm or manipulator." The line from surface ship Mizar, which was attached to the bomb March 24, fouled either on an anchor or a granite outcropping and snapped. It rolled down the slope to 2,800 ft. where it was lost for another nine days.

When found by the Alvin again April 2 (this was done by following the trench formed when the bomb slid down the slope), the "bomb was in constant danger of rolling into a deeper narrow canyon where salvage could have been impossible."

CURV, the remotely controlled unmanned vehicle designed for torpedo recovery to 2,000-ft. depths, was modified for work to 3,000 ft. and flown in from California. After several false starts, CURV was guided into position over the bomb by sonar and television cameras where she attached two grapnels to the bomb. The vehicle became permanently tangled in the bomb, so "CURV, parachute and weapons were brought to the surface by the USS Petrel, a submarine rescue ship." ■



Lockheed Tests Hot-Gas Thrust Vector Control

Gases rush from three nozzles on 156-in.-dia. solid rocket motor successfully fired by Lockheed Propulsion Co. during recent test of hot-gas valve system for controlling direction of rocket thrust. Two smaller nozzles are overboard ports for two hot-gas valves mounted on main nozzle. They bleed gases from main combustion chamber and either vent it overboard or inject it into main exhaust, diverting thrust.

2.75-in. Rocket Fuze Production Gains

by Charles D. LaFond

WASHINGTON—Selection of four new contractors to produce 2.75-in. folding-fin aircraft-rocket fuzes (M423 type) for helicopter use, and a new simplified fuze design out of Picatinny Arsenal will greatly increase next year's supply of the vital rocket assemblies (M/R April 18, p. 16).

New contractors, now undergoing facility inspection by the Army, are Fairchild Camera and Instrument Co.; Motorola, Inc. (Chicago Center); Parker Pen Co.; and Wittronics, Inc., a subsidiary of Longines-Wittnauer Watch Co. Contracts, to be awarded by Picatinny, are expected to total $1.5-2 million each for the first year.

The redesigned 2.75-in. rocket fuze, expected to go into full production this summer, will permit detonation at almost any impact angle. Present M423 and M427 fuzes must impact at no more than a 45° angle with the target to assure detonation. In addition to improved performance, the new fuze will require considerably less machining.

Production gains noted—Fuze production for the month of April is expected to approach 400,000 units total, with at least two manufacturers nearing the 100,000-unit-per-month output. All of the present six producers (Avco, Bulova, Gibbs Mfg. & Research, Hamilton Watch, KDI Corp., and Westclox) are expected to reach the 100,000 mark by June. March production stretched to about 285,000. Less than 250,000 were manufactured in February.

Informants indicate, however, that a leveling off by some fuze makers may occur at the 100,000 level. A few are planning to reach the 150,000 unit total called for by the Army by the year's end.

The four new M423 fuze manufacturers are not expected to produce much before six to eight months. All are planning a rapid build-up after initial production to 100,000 per month. There are indications that the requirement of Secretary of Defense Robert S. McNamara for an ultimate production of 800,000 fuzes a month will not be considered a ceiling. The Army is believed to be planning to buy all fuzes that can be produced during the next several years.

New fuze design—MISSILES AND ROCKETS has learned that a new fuze design is due from Picatinny Arsenal late this spring. While embodying the same safeing and arming mechanisms currently used in the M423 and M427 fuzes, the new fuze will employ redesigned body cones.

Present fuzes employ two body assemblies containing the striker and firing pins. These require threads and are screwed together in final assembly. The new design will permit a shrink fit for connection of the two parts, greatly reducing the number of separate machining operations (now totaling 60).

Some manufacturers are already tooling up for the new parts and have produced a limited number for testing.

Details of the new fuze have not been released yet (nor are they expected to be for some time) but it is believed that the new fuze head will permit detonation at almost any impact angle. The present M423 fuzes will detonate at any angle to 45°, but with helicopter launch, the trajectory often is so flat that rockets bounce off targets without exploding.

Machine-tool problem—Refurbishment and setup of machine tools for the production of fuzes appears to have caused a senseless waste of valuable time. Such machines, semi-automatic and automatic, have been stored, largely in Government depots, between wars and were supposed to have been "mothballed" in a condition so that when needed they could be rapidly reintroduced to U.S. industry for immediate use. This apparently has not proved to be the case.

Industry informants have disclosed to M/R that some refurbishment of tools has required up to a 50% overhaul to bring machines up to working readiness. Units have been stored in inoperable condition; others have suffered cannibalism of much-needed parts.

Because of the need to expand parts production to support the Vietnam effort, machine-tool refurbishment needs create a chain reaction. Thus, fuze builders must go back to the original machine-tool maker for replacement parts—sometimes waiting from 18 to 24 months to complete a machine. The impact on the toolmaker is sharp because he too is under pressure to build more machines for other uses.

In the meantime, the fuze manufacturer must cannibalize from one machine to get another into operation. Further delays often are encountered in obtaining production tooling to complete setup of machines for the specific production pieces.

Other problems—Reportedly, some fuze manufacturers have experienced difficulty in obtaining metals, principally raw-stock aluminum. Others have found difficulty in obtaining key parts from vendors—chiefly the finely machined rotors and pinion stock used in the safeing and arming device.

The lack of a meaningful military priority system, manufacturers say, limits the pressure that fuze makers can apply on vendors. The latter feel they have prior commitments to older customers who will still be around long after the Vietnam need fades away. They intend to keep these regular clients and thus military contractor needs are satisfied secondarily.

Real preparedness needed—In attempting to find an answer to the problem of maintaining industrial readiness, M/R conferred with many U.S. manufacturers to obtain a consensus. The problem is certainly not unique to 2.75-in. fuzes or all fuzes, but to all the urgently needed war materiel.

However, 2.75-in. rocket fuze production can serve as a typical example as can possible solutions to preparedness for their future production.

Between wars, military in-house laboratories are generally sufficient for maintaining a low-level R&D effort. But industry must be given facilities contracts whereby needed machine tools can be maintained in operating condition at all times. Further, industry informants assert, limited production contracts must be continued to assure the existence of key skilled workers capable of serving as a cadre for future production expansion when needed.

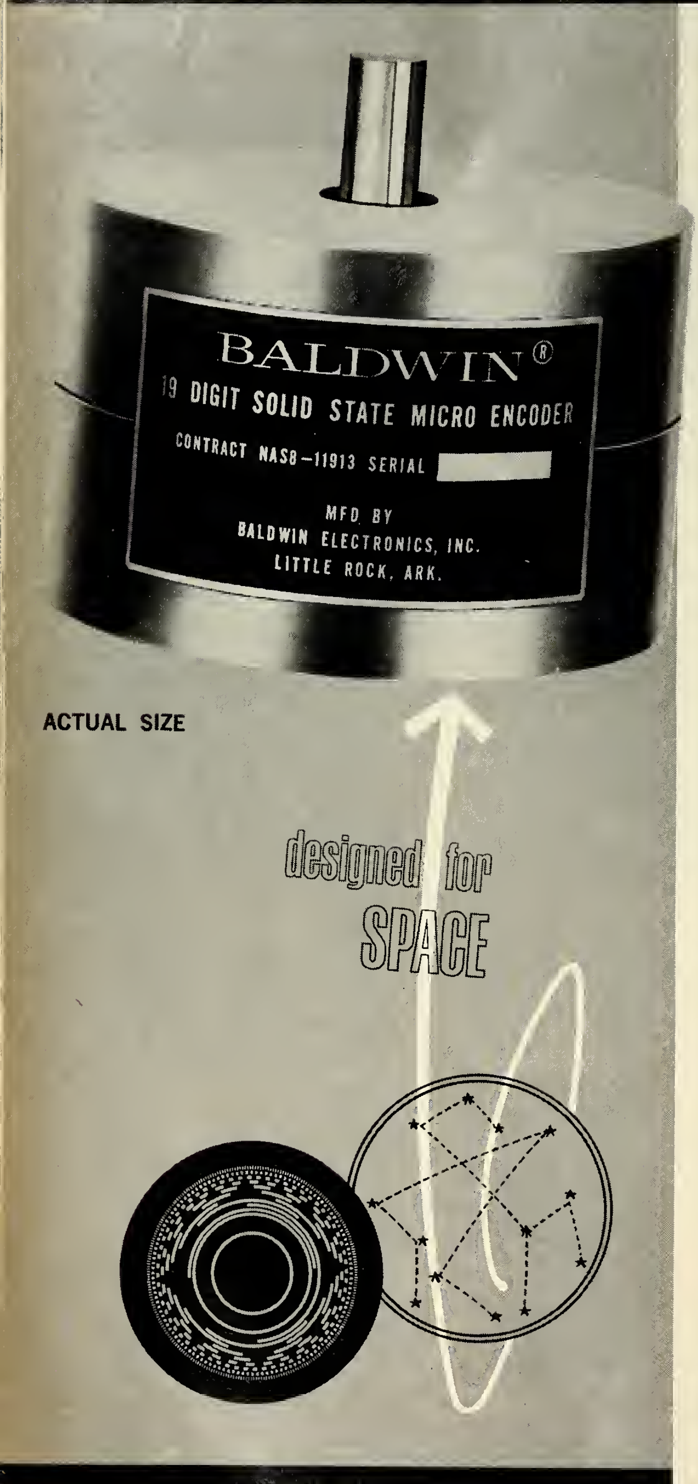
In addition, there must be good liaison between the military developmental labs and industry to facilitate changeover of production tooling for new hardware designs.

Obviously, every firm capable of manufacturing fuzes need not be maintained as part of a readiness program. The best approach might be to select those firms most closely associated with the fuze in their consumer or commercial production. Thus, U.S. watch manufacturers might be selected for fuzes. The next step would be to assure that each is capable of 100% fuze-parts production.

Finally, arrangements probably could be made for part-time use of machine tools on a rental basis for non-military production by the contractors. Machines in use, manufacturers say, are better kept in operating condition.

The result of such a preparedness approach would mean the assured availability of an industrial nucleus to produce precision parts and assemblies whenever needed. Only the rapid release of strategic materials would be needed for immediate production. Further industry expansion could be made as needed, but in the interim inventories could be built up rapidly on a crash basis. ■

State-of-the-Art Breakthroug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Baldwin Electronics, Inc. is proud to announce a completely new concept in shaft angle encoding that is not available from any other manufacturer. This represents a breakthrough in the "State-of-the-Art" for Photoelectric Shaft Position Encoders.

A 2^{19} Absolute Position Encoder, 3.9 inches diameter and 2.5 inches long, was recently developed and delivered on Contract NAS8-11913 for the National Aeronautics and Space Administration, Marshall Space Flight Center.

The advanced technologies used in the design and development of this Encoder will be presented in a paper entitled, "A Miniature 2^{19} Encoder", by Mr. Herman E. Thomason, NASA, at the ISA Aerospace Symposium in Philadelphia. Mr. Thomason is Deputy Chief, Inertial Sensors and Stabilizers Division, Astrionics Laboratory at Marshall Space Flight Center. The Encoder will also be operating on display at the Symposium.

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ELECTRONICS

Laser Market May Reach $1 Billion by 1970

The continued rate of growth in the laser field could result in a $1-billion market by 1970. Charles H. Townes, Massachusetts Institute of Technology Nobel Prize winner, told the 1966 International Quantum Electronics Conference in Phoenix, Ariz., April 12-15, that he does not consider this an "unreasonable estimate." Following a burst of enthusiasm for lasers, there was a slump in interest when the advantages promised were not realized overnight, Townes said. However, the situation is changing and "it seems to me that we are now on the upgrade," he added.

300-Watt Carbon Dioxide Laser Described

Results of investigations of carbon dioxide lasers, able to generate up to 300 watts of continuous power at 10.6 microns, were presented to attendees of the 1966 International Quantum Electronics Conference, meeting in Phoenix, Ariz., April 12-15. C. K. N. Patel of Bell Telephone Laboratories described the lasers in a paper given at the conference. These have applications in fabrication techniques such as welding, in communications through the 8 to 14-micron atmospheric window in the infrared, and in nonlinear optics systems. By Q-switching the CO_2 laser, peak pulse powers of greater than 10 kw can be obtained, enabling generation of a second harmonic in tellurium crystals at a level of several watts peak.

Apollo Radars Aligned with Laser

Radar alignment equipment, which includes a laser subsystem, has been developed by Perkin-Elmer Corp. for use by the *Apollo* re-entry tracking range ships. Developed under a $575,000 contract from LTV, Inc., prime contractor for the modified vessels, the automatic antenna-flexure monitor systems are to be employed to sense and measure any angular deviations experienced by the big radar-antenna pedestals along three axes. These variations will be combined with other navigational data, fed into a computer, and used to correct apparent radar tracking trajectory readings. A helium-neon laser will provide long-path illumination for a polarimeter system used to monitor roll-axis deviations. Pitch and yaw deviations will be measured by a dual-axis autocollimating star-tracker.

Compact Linear Accelerator Delivered

Measuring one-third the size of comparable output systems, an electron linear accelerator has been delivered to Ohio State University by Varian, Inc. The unit is capable of beam currents exceeding one ampere at 6 Mev for 10 nanoseconds. The compact accelerator will be used for pulse radiolysis studies of short-lived intermediaries.

Non-Laser Optical Radar Demonstrated

A short-range, non-laser optical radar system using a small, intense arc lamp has been demonstrated by Dr. Heinz Fischer, Air Force Cambridge Research Laboratories. The system has been successfully tested on targets 100 ft. away, and a more sophisticated version may be able to detect and range objects as far away as 1,500 ft., Fischer has said. The unit consists of the arc lamp—called the Nanolite—a collimating lens, a photoelectric detector and an electronic timing device. According to Fischer, the system offers a number of advantages over conventional and laser radars.

PROPULSION

Rockets Contaminate Ionosphere

A major source of error in data obtained from electron-density rocket probes has been created by rocket motor outgassing in the ionosphere, according to scientists at the Air Force Cambridge Research Laboratories. The leakage and subsequent diffusion of left-over fuel after burnout introduces a space contaminant that has caused puzzling anomalies to researchers analyzing sounding data. These have shown up as discrepancies between electron density measured at a given altitude on the upward path and that measured at the same altitude on descent.

Fizz Aids in Sloshing Studies

Common effervescent tablets are being used by Douglas Missile and Space Systems Div. in the study of sloshing liquid rocket fuels. The fizz stream from such tablets, researchers said, permits a quick look at the behavior of a liquid column from top to bottom. Colored dyes, used previously, provided good surface reaction data but were of little use in studying sub-surface motion. As a result of the new technique, Douglas said, improvements in tank baffle location have been made and better locations for liquid-motion sensors have been found.

LIFE SUPPORT

Nuclear Protection System Developed

The Navy's explosive lens flashblindness (ELF) protection system is nearing production, according to spokesmen from Johns Hopkins University Life Sciences Group and the Navy. The equipment consists of the ELF lens or goggle, a sensing device to detect a nuclear-detonated electromagnetic-radiated signal and a battery-operated discriminator unit called the trigger, which is electrically connected to the lens and sensor. Reception of a signal triggers a reservoir containing opaque material, which is released into a void in the lens system, occluding the transmission of incident light. The opaque material utilizes oleic nitrile as a carrier and has operated satisfactorily from $-65°$ to 65°F.

Bacteria-based Life Support System Progresses

NASA reports encouraging progress in the study of hydrogenomonas bacteria as a foundation for a regenerative life-support system. It now appears that a 20-liter culture with 10 grams dry weight of bacteria per liter will utilize the waste carbon dioxide and urine from an astronaut and the hydrogen from electrolysis in supplying oxygen to the astronaut. Power requirement for electrolysis is about 0.75 kw/hour continuous. A 20-liter unit for supporting one man is being built. Rat feeding experiments have been undertaken to determine the nutritive values of the bacteria; to date, no toxic materials have been discovered.

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'Live' Mirror Adapts Itself to Space

by William S. Beller

WASHINGTON—Active optics—a new technique for building self-correcting astronomical mirrors—may point the way to large orbiting telescopes.

The surface of an active optical mirror is made up of a number of "tiles" much like those on a bathroom floor. Each tile can be minutely positioned until the figure of the mirror is the required one.

This means that temperature or gravity gradients in the mirror possibly can be corrected as they arise. An accurately figured telescope on Earth conceivably could be even more accurate in space and could result in a diffraction-limited 120-in. or larger space telescope.

A *Saturn V* could lift a 120-in. telescope into orbit fully assembled. In fact, this launch vehicle could carry an assembled telescope with a primary mirror up to 250 in. diameter if there were no other engineering considerations.

But if packaging becomes a problem, particularly for very large astronomical instruments, the mirror tiles or segments could be stacked one on top of another, or in other ways, to form a payload of a size and volume amenable to the launch vehicle.

The Perkin-Elmer Corp., in disclosing its active-optics work to MISSILES AND ROCKETS, said the concept will have its first systems checkout this July. At that time, a 20-in. spherical mirror will be cut into segments after figuring and used "to demonstrate the proposed figure sensing and actuator control techniques," Hugh J. Robertson told M/R. He is a senior physicist at the company and manager of its active-optics work.

Large telescope value—A large diffraction-limited telescope in space would certainly be of "very vital importance in astronomical research for many years to come," the Space Science Board (National Academy of Sciences—National Research Council) wrote in its report on suggested directions for space research, released earlier this year. This opinion was emphasized at the time by Guido Munch of Mt. Wilson and Palomar Observatories, who said, "Indeed, every one of the outstanding astronomical problems of our time requires high resolution (telescopy) for further understanding."

Guido singled out such outstanding problems of current interest as finding the angular dimensions of quasi-stellar radio sources and the structure of the nuclei of galaxies, resolving galaxies into stars to refine the distance scale, and studying the faint end of the population of clusters of galaxies and stars.

He pointed out that a field of view as small as 20 arc-seconds, truly diffraction-limited, say with a resolution of 0.03 second, would provide information needed to help solve these important problems. This resolution is what Perkin-Elmer claims an active-optics telescope with a 120-in.-dia. primary mirror could be designed to give in space.

The Perkin-Elmer work is one of various technical studies sponsored directly or indirectly by NASA to look into the technical feasibility of diffraction-limited 120-in. space telescopes. The Boeing Co. and the American Optical Co. are also working on the problem. The Space Science Board believes that such a large orbital telescope, not necessarily with active optics, could be developed and launched by 1979.

Problems with telescopes—There is little likelihood that a telescope will ever get high-resolution pictures from the Earth's surface. First is the problem of the varying atmospheric refraction of starlight—bad seeing. Atmospheric turbulence, in fact, has limited the best resolution obtainable up to now to 0.3 arc-second, the diffraction-limited resolution of a 12-in. telescope.

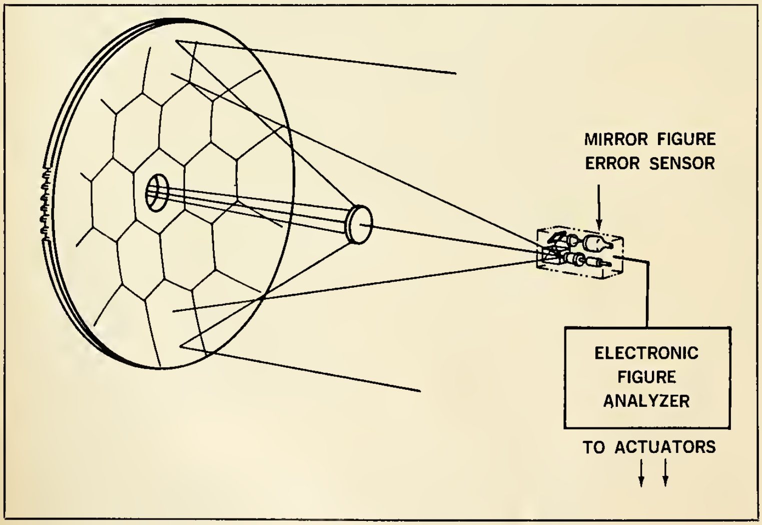
Then there is the problem created by the distortion of large mirrors under the pull of gravity. The first problem can be overcome by using the telescope in space; the second by active optics if the technique proves out.

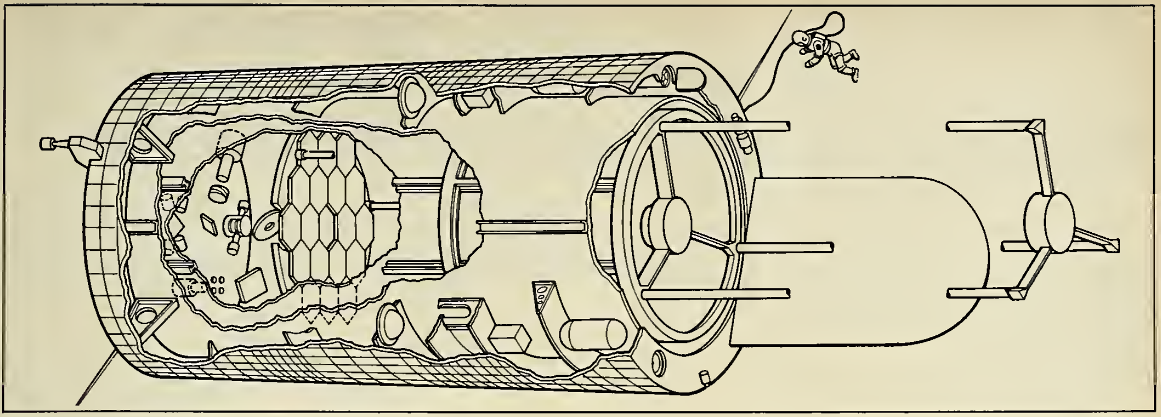
Simply orbiting a telescope in a zero-gravity environment does not automatically solve the problem either of acquiring or keeping a near-perfect mirror. Gravity limits the mass of mirror that can be launched. In turn, the mirror's weight limits the body's diameter and thickness. Thus, rigidity is affected and correspondingly the size of the mirror because it must be tested and figured in the Earth's gravitational field before it goes into space.

However, if the mirror can be made reasonably accurate on the ground and subsequently adjusted by active optics in space away from the strains introduced by gravity, a relatively large mirror can be constructed without excessive fear about errors introduced by the Earth's gravity.

Temperature gradients, too, particularly in large mirrors, can distort images considerably unless some protection is given to the mirror or it is made self adjustable. In this regard, Lyman Spitzer, Jr., Princeton University Observatory, has shown in a paper on space astronomy that a temperature difference of only 0.02°C, when it occurs across

Active-optics telescope system has self-adjusting "tiles" to reach accurate figure.





Schematic of large active-optics orbiting astronomical telescope system. Note active-optics tiles that form the primary mirror.

the thickness of a 10-meter, 20-cm.-thick mirror, could cause a serious loss in resolution. But in an active-optics system, the temperature requirement would be considerably relaxed because it would apply only to a mirror the size of one of the segments of the overall mirror. Each segment would be independently controlled and positioned to maintain the mirror figure, including corrections for changes owed to thermal variations.

Weight savings—Robertson said that for the same maximum allowable flexure, the segments of the active-optics system could be considerably thinner than a single large conventional mirror, resulting in a very large weight reduction. For instance, a 100-in. primary mirror of fused-silica egg-crate construction having the same stiffness as the 32-in. primary mirror for *Orbiting Astronomical Observatory-C* (*OAO-C*) would weigh about 3,000 lbs. This contrasts with a weight of less than 800 lbs. for a 100-in. segmented primary consisting of seven 32-in.-dia. mirrors including control electronics.

Similarly, a 10-meter primary of fused silica only 25-cm. thick would weigh about 110,000 lbs., according to Robertson. He said that the same mirror built on an active-optics scheme could weigh less than 20,000 lbs.

Active-optics system—The mirror segments are positioned and the shape of the composite surface maintained by precise actuators able to make displacements of less than one micro-inch. The actuators are part of a closed-loop control system operating from signals originating from interference phenomena generated by a sensing system. This sensing system can continuously monitor surface orientation of the mirror segments.

The proposed sensing system would be near the center of curvature of the primary mirror. It would consist of laser and white-light sources, interferometers, and would make use of a means to convert interference fringes into appropriate electrical signals.

An electronic analyzer would use the information in the electrical signals to produce the outputs needed to control the actuators for the proper orientation of the mirror segments. The actuators for each segment would allow three degrees of freedom: a pivot around two orthogonal axes and a translation normal to the segment's surface.

To evaluate the active-optics concept for use in a spaceborne telescope, Perkin-Elmer is building and will check out a 20-in. spherical mirror. As in an actual orbiting system, the mirror surface will be made up of segments and will produce an interference pattern at the output of the figure sensor interferometer. Figure analyzer circuitry will produce an error signal when the interference pattern shows a displacement of the segments from a spherical surface.

In turn, this error signal will be applied to the appropriate actuators to re-position the mirror segments and reduce the error.

Technical problems—Both Robertson and Jack Murkland, marketing manager for Perkin-Elmer space optical department, admit there are a number of technical problems in active optics still to be solved. But these problems all have theoretical solutions, and it is the engineering physics that remains to be done.

"First, we are trying to determine the optimum figure-sensing technique," said Robertson. He noted there are several interferometer techniques to choose from. An interferometer using laser light is proving very effective for sensing fractional wavelength displacements by measuring differences of the interference phase across the image of the primary mirror.

But a fundamental difficulty appears here since the axial displacements of one segment relative to another by an amount equal to a relatively large number of half wavelengths of the single-frequency laser used does not necessarily affect the phase difference at the output of the interferometer.

This phenomenon, which Robertson calls "integral wavelength ambiguity," does not produce a variation in phase that can be detected by scanning across a segment until several wavelengths of relative axial displacement exist. To resolve these ambiguities, Perkin-Elmer is investigating several different schemes involving white-light and two-wavelength laser interferometers.

The company is also developing the electronic circuitry needed to analyze the figure sensor output and provide the error signal to operate the actuators.

Another company effort calls for devising very accurate fractional wavelength actuators to move the mirrors. Robertson named some of the requirements for an ideal actuator:

—Ability to make reversible displacements of a small fraction of a micro-inch.

—Large dynamic range. If mirror segment positions require an initial adjustment of as much as 0.02 in., the ratio of the dynamic range to smallest step needed is greater than 100,000 to 1.

—Zero power requirement when displacements are not being made.

—Ability to maintain final position in the event of power failure.

—Ability to operate in a space environment.

There are many possibilities to satisfy these requirements in various configurations of piezoelectric crystal arrays, magnetostriction devices, electro-mechanical arrangements, and thermal and chemical actuators.

"We are confident that the active-optics approach will prove to be an effective one for large-aperature orbiting astronomical telescopes and that it may find application in large ground-based telescopes as well," said Robertson. ■

Aluminum-Steel Plate Bests Titanium

by John F. Judge

COCOA BEACH, FLA.—Production techniques for the fabrication of aluminum-steel wire composite plate are in an advanced stage of development at Harvey Engineering Labs., the research and development division of Harvey Aluminum Co.

The end result is plate with the strength of the best titanium, with a density about 85% that of titanium. The development was described by Leroy W. Davis of Harvey and Wayne R. Morgan of NASA's Marshall Space Flight Center before the Seventh Structures and Materials Conference, sponsored jointly by the American Institute of Aeronautics and Astronautics and the American Society of Mechanical Engineers here last week.

The Harvey work is under contract to Marshall Space Flight Center. The original aim was to achieve a combination of a minimum tensile strength of 175,000 psi at room temperature with a maximum density of 0.144 lbs. per cubic inch.

The target represented a somewhat higher strength-to-weight ratio than the best titanium alloys currently in production in 1963, when the program was initiated.

After a series of projects involving various aluminum alloys and high-strength wires together with several production approaches, the Harvey researchers settled on a combination of 355 stainless-steel wire and 2024 aluminum alloy.

Specifics—Characteristics of the composite include:

Wire diameter—0.009 in.

Ultimate tensile strength of wire—480,000 to 520,000 psi.

Ultimate tensile strength of composite—172,000 to 176,000 psi.

Density—0.145 lbs. per cu. in.

Young's modulus—15 x 10^6 psi.

Strength to weight—1.21 to 10^6 in.

Ultimate tensile strength at minus 320°F—215,000 psi.

Ultimate tensile strength at 700°F—over 100,000 psi.

Davis says the approach chosen was dictated by a proper distribution of the steel wire in the aluminum matrix and amenability to the production of usable forms such as sheet and plate.

The concept consists of producing a basic unit containing the proper distribution of wire in the aluminum matrix and then subsequent consolidation of these units to form structurally useful material.

These considerations led to the use of aluminum sheets, with the steel wire distributed uniformly between the sheets and consolidation by diffusion-bonding of aluminum to aluminum around the steel.

A combination of heat, pressure and

Pollution Poses Knotty Spacecraft Problem

COCOA BEACH, FLA.—The contamination of spacecraft atmospheres on long-duration missions by trace amounts of toxicants generated by various space-cabin materials and chemicals is shaping up as a tough materials problem.

Dr. Kenneth C. Black, chief of the toxicology branch of the toxic hazards division of Aerospace Medical Research Laboratories, Wright-Patterson AFB, has called for a thorough toxicological evaluation of such closed-system atmospheres.

Black told the AIAA materials meeting that the aggravating factors in contaminant concentration are far more numerous that those that can alleviate the problem. "The limited volume of usable atmosphere in space systems allows for very little latitude in air-pollution control," he said.

Air-purification and life-support equipment are being heavily taxed with increasing mission lengths, and can *per se* change the total contaminant picture by incomplete processing of toxic materials.

The state of the art in environmental toxicology does not allow valid prediction of human tolerance to any toxic material for prolonged, continuous exposure.

Moreover, Black said, the bizarre mixture of any contaminants always carries the threat of potentiation of toxic effect by individual constituents within the mixture.

Exotic environments such as low barometric pressure, 100% oxygen atmosphere and the multitude of physiological and psychological stresses are still unknown quantities that can have a profound influence on man's resistance to chemical insults.

Similar to air-pollution problems on Earth, freak coincidences of relatively harmless factors could lead to severe biological embarrassment.

Black claims it is also quite obvious that the problems on nuclear submarines are far less serious than those in the spacecraft environment.

Uninterrupted 90-day continuous exposure to contaminant concentrations not exceeding the threshold limit value has resulted in 100% mortality of animals with certain chemicals.

The Air Force is using a $1.5-million toxic hazards research unit in probing these problems. The facility was built by Aerojet-General Corp. and is staffed by both Aerojet and AMRL personnel.

Targets—Black says a cooperative NASA-Air Force effort is now exploring five basic questions:

—Does 5-psi 100% oxygen atmosphere cause pulmonary irritation or functional impairment during 14-day to one-year exposure?

—Will a 5-psi 100% oxygen atmosphere influence tolerance to toxic materials, especially to pulmonary irritants and systemic poisons?

—Will a 5-psi mixed gas (70% oxygen, 30% nitrogen) atmosphere influence tolerance to toxic materials?

—Should space-cabin materials be screened for toxic properties singly or in mixtures?

—Are there differences in gas-off properties of space-cabin materials at the 5-psi vs. the mixed-gas atmosphere?

—What are the chemical gas-off profiles of compounds exposed to single and mixed-gas atmospheres for 30, 60 and 90 days?

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INFRARED Design infrared signature acquisition system for launch and re-entry coverage.

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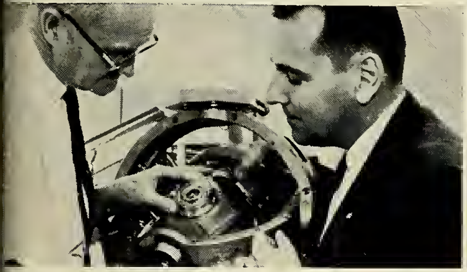

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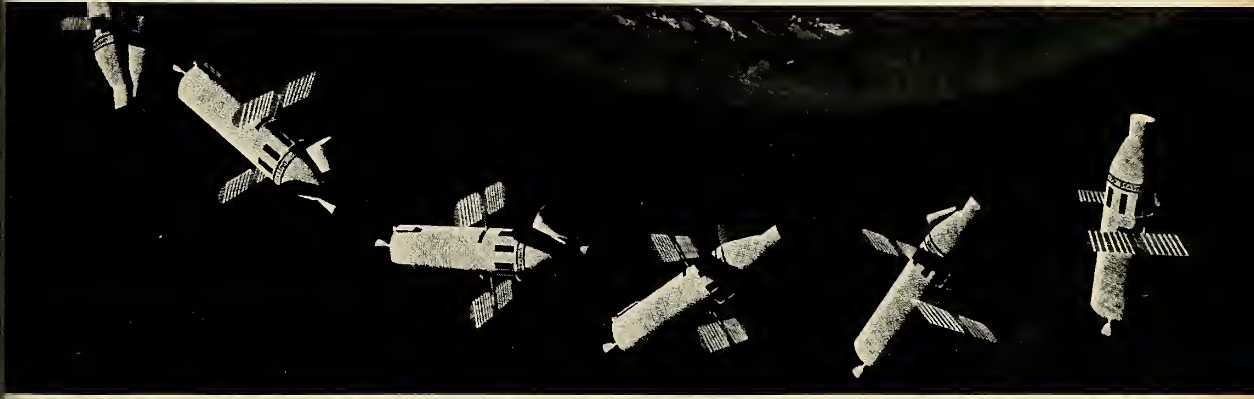

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plastic deformation produces the composite. Coatings and explosive bonding have also been investigated.

The bonding work broke down into two areas—matrix to matrix, and matrix to reinforcement. The aluminum-to-aluminum bond is metallurgical and research at Harvey indicated that the best wire-to-aluminum bond is mechanical, without a metallurgical reaction.

Various aids were used by Harvey to improve the diffusion-bonding of the aluminum to itself. Aluminum strips have been coated, either singly or in combination, with lithium, indium, tin, zinc, silver and copper. While some of these materials allowed a reduction in the bonding temperature, none provided improvement sufficient to encourage the researchers to continue their use. Optimum bond was achieved by eliminating all additions and using clean surfaces. Mechanical cleaning proved practical—and provided the best results.

Material degradation problems limited the bonding temperature to the 900-925°F range, and Harvey experts achieved bonding in about 20 minutes using pressures as high as 14,000 psi.

Plate production—The sheets are fed under a wire brush arrangement and then assembled with the wires immediately after cleaning. The material is encased in a steel can which is evacuated, flushed, re-evacuated and filled with argon. The can is then sealed, preheated to pressing temperatures, evacuated and hot-pressed for bonding.

The operations were worked out on small 2 x 8-in. samples plated in a variety of thicknesses ranging from 0.040 to 0.75 in. The next step involved fabricating 2-ft.-long plate and then tooling up for the specified composite 1 ft. wide, 8 ft. long in thicknesses of 0.25, 0.75 and 0.04 in.

After the bonding operations, Harvey researchers developed a series of methods designed to obtain maximum properties. They established that, with good bonding, the tensile properties of the composite are consistently within the range of 95-100% efficiency based on the law of mixtures—the strength of the wire times its area percentage plus the strength of the matrix at composite strain times its area percentage.

The standard sequence of operations for plate at Harvey is diffusion-bonding by hot-pressing; flattening to uniform thickness by hot-rolling; solution heat-treat; cold-rolling for 2% reduction in thickness; artificial aging and final cold-rolling for another 2% reduction in thickness.

The hot-rolling corrected the minor variations in thickness existing after the diffusion-bonding operation. These variations result from overlapping steps in the bonding process.

The preparation of test samples from the plate involved electrical discharge machining as the optimum method.

Davis listed several applications, the primary one being liquid-oxygen containment. Other areas of interest include compressor blades and jet-engine components where a high specific modulus is desirable.

There is a distinct possibility that this material may be used in strip form to build up structures in the same way as glass-epoxy composites.

Davis says costs of the steel-aluminum alloy composite certainly will be much lower than composites with any of the other continuous filaments now under consideration. "With the cost of raw material in the vicinity of $3.50 per pound, it is not unreasonable to anticipate composites of aluminum and steel wire being marketed in the $5.00 to $10.00 area."

Harvey researchers have used the basic technique to fabricate boron fiber-aluminum matrix samples as well as beryllium wire. The boron contributed about 100,000 psi to the strength of the composite and Davis says tests of the fiber had indicated this was to be expected. In these tests, it appears that the weak spots in the boron filament break first, overloading the stronger portions and producing failures in the low value. Tests are continuing with more recent lots of the high-priced boron fiber where the reinforcement seems to be more uniform.

Other points—Structural design challenges in the current materials revolution are now at the point where major configuration decisions increasingly hinge on the feasibility of advanced structures and of certain essentially structural components.

Roger A. Anderson, chief, Structures Research Div., NASA Langley Research Center, characterized the problem with the remark that people "talk composites but think metals."

Anderson says time is evidently needed to experiment and evolve a new design and construction technology for composite material that is not bound by past practice with other materials.

Specific structural areas where composite materials may find future applications are large space mirrors and antennas, sustained high-speed flight and deceleration and landing systems.

R. A. Tanzilli and E. G. Menkes of General Electric Co.'s Re-entry Systems Dept. detailed an analytic and experimental approach to the difficult problem of evaluating graphite composites for re-entry applications.

The presentation of Tanzilli and his co-workers typified the major flavor of the materials sessions at this meeting. Most of the papers were concerned with the basic problems inherent in realizing the full potential of the many new materials emerging from research.

Shell theory, design and analysis, material development and production, joining, environmental effects, cost and time include vexatious problems which must be solved before the new materials can be fully utilized.

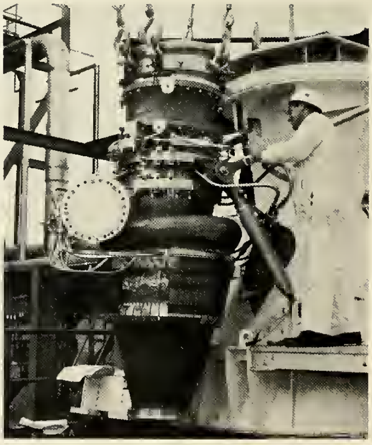
The new combinations of materials scientists with designing engineers is evident in a beryllium-aluminum alloy program described by H. Armstrong and A. B. Burns of Lockheed Missiles & Space Co. and R. G. Crawford, Advanced Systems Office, NASA-Marshall.

The effort showed that large weight savings in future space vehicles are economically possible if new or improved materials are joined with optimum structural design methods.

Optimum structures of Be-Al alloys proved to be 50% lighter than optimum aluminum structures for applications to current upper-stage vehicles.

While structures more heavily loaded show smaller weight savings — in the 30% area—these proved to be significant in view of payload costs. The cost study coupled in the alloy design development program showed the cost per pound of weight saved to be reasonable and indicated that immediate consideration of beryllium-aluminum alloys for primary structures is warranted.

In addition, the Lockheed experts used computer programs that produced a depth of previously unavailable detail in useful stress, weight and configuration data. ■



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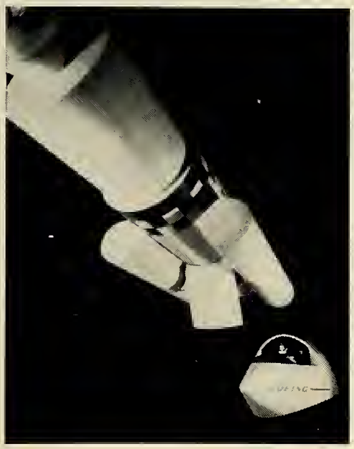

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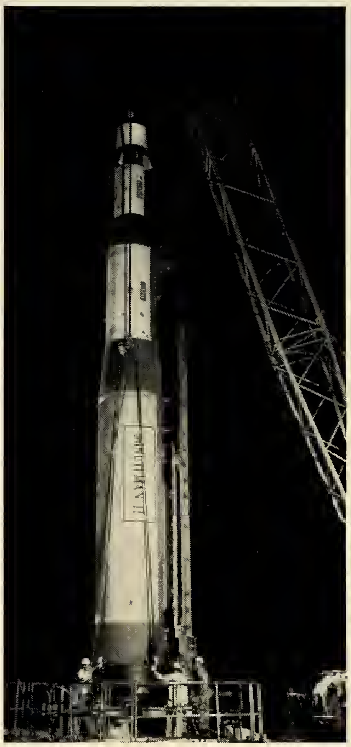

Advanced Minuteman II ICBM incorporates many improvements, including larger payload capacity, longer range, more sophisticated guidance system, increased accuracy.

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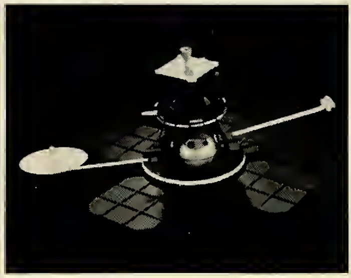

First Lunar Orbiter flight, scheduled for mid-1966, will seek out Apollo landing sites with sharp, detailed photographs of moon's surface. Boeing is building eight Orbiters for NASA.

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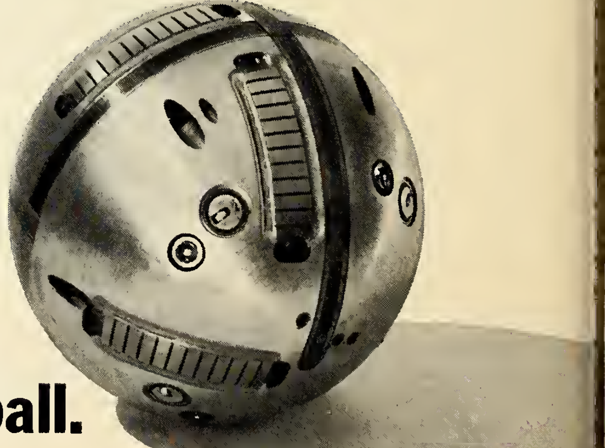
Northrop is going to build the navigation system for the Lockheed C-5A.



It'll be a ball.

t of the C-5A's doppler-inertial navigation system be a ball-shaped inertial platform floating in a rical container.

side the ball will be three gas-bearing gyroscopes, e pendulous accelerometers, and the platform ronics.

ne floated ball has no mechanical gimbal. This s parts, complexity and weight, and makes the orm extremely rugged.

ne unique device is called FLIP (Floated Lightht Inertial Platform) and was developed by Norths Nortronics Division.

orthrop has also developed the tiny computers giant capacity which will be used in the system. are an outgrowth of Northrop's NDC-1000 aire computer which weighs only 35 pounds yet has problem-solving ability of the largest earthbound hines.

ne entire C-5A system (including the stable plat, computers, doppler radar, and displays) will weigh just over 200 pounds.

It will have a positional error of less than 1 mile per hour of flight.

A substantial reserve computer capacity is built into the system to permit additional guidance or flight management computation.

The C-5A system grew out of Northrop's NIS-105 navigator which is under evaluation by the United States Air Force at Holloman Air Force Base.

This will be the first time a doppler-inertial navigation system has been installed on a large transport aircraft. A fixed-price contract for development, test, and production of the complete system was awarded to Northrop by the Lockheed-Georgia Company, builders of the C-5A for the U.S. Air Force.

Engineers who would like to join the Northrop team on this project should write to George C. Richards, Northrop Nortronics, 2301 West 120th Street, Hawthorne, California.

NORTHROP

Army Developing Fog-Piercing Millimeter-Wave Imaging Unit

by Rex Pay

PHOENIX, ARIZ.—The Army Electronics Command, Fort Monmouth, N.J., is developing a system that converts millimeter wave images into visual images to enable Army viewers to see vehicles and similar objects through 300 yards of fog or smoke.

The aim is to produce a simple compact unit for ground and aircraft.

Work began on the imaging system in anticipation of availability of practical laser sources of millimeter and submillimeter radiation in the near future, Harold Jacobs, senior scientist at Fort Monmouth's solid-state division, told the 1966 International Quantum Electronics Conference held here.

Because 3-mm radiation penetrates fog very well, a beam from a laser source of this wavelength could function as a searchlight. Radiation reflected back from targets in the fog would then be converted to a visual display by the imaging system.

Nuclear strike use—Since smoke is likely to be used to attenuate nuclear radiation, an imaging system such as this will be of considerable value for vehicles and aircraft in nuclear warfare.

Development of millimeter and submillimeter lasers has been one of the noteworthy developments since the last International Quantum Electronics Conference in 1963, said Charles H. Townes in a keynote address to the conference. He cautioned, however, that there was more work to be done before such lasers would work "comfortably and conveniently."

Currently in the early stages of feasibility demonstration, the Fort Monmouth millimeter-wave imaging system has so far shown a capability of detecting and displaying point sources against a background.

Initial work has been with conventional microwave sources, starting a few years ago at 10 gc and more recently operating at 70 and 90 gc.

The system makes use of the properties of semiconducting materials that transmit or absorb millimeter radiation. By changing the conductivity of these materials by means of a light beam, changes in the degree of reflection or transmission of millimeter radiation can be achieved.

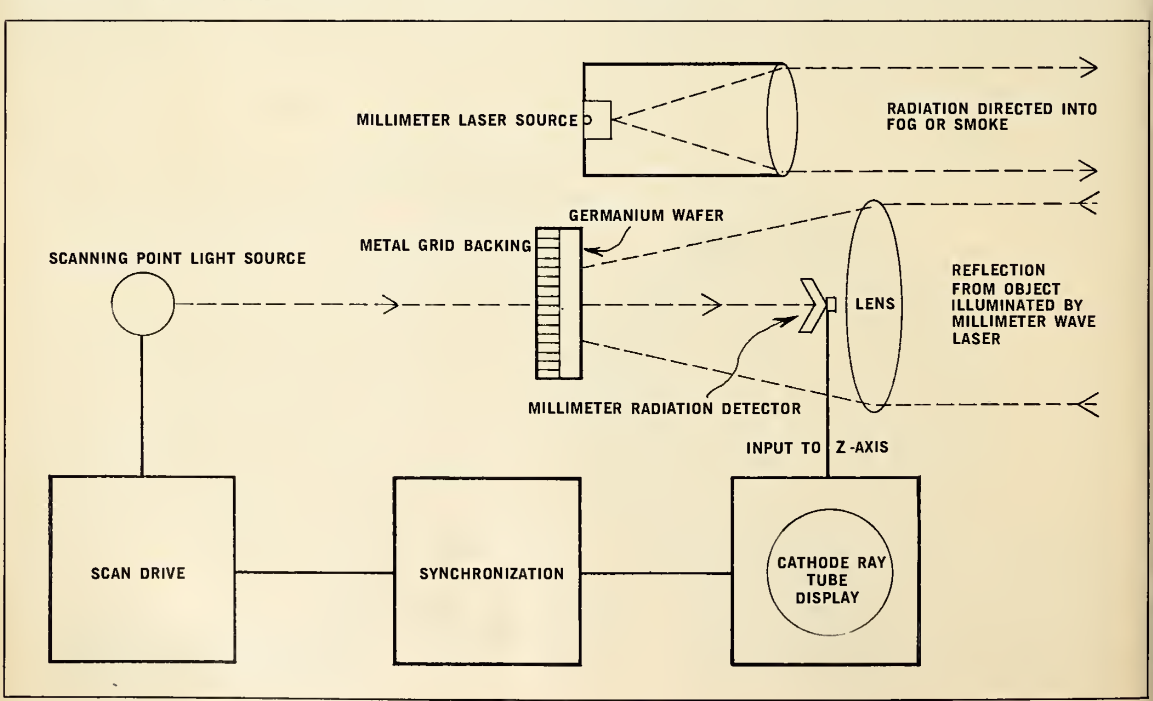
Experiments at Fort Monmouth have shown it possible to produce both phase and amplitude changes in the reflected signal. It is also possible to produce phase changes and no amplitude change or to produce amplitude changes without phase change. Thus it is possible to modulate millimeter radiation by varying the conductivity of a semiconductor. By choosing a critical thickness of semiconductor, resonance effects can be obtained.

Either the transmission properties or the reflection properties of a semiconductor can be used to produce an imaging system, but reflection is preferred because it yields a better signal-to-noise ratio.

How it works—In the system developed at Fort Monmouth, incoming millimeter-wave radiation is focused by a lens onto a semiconductor slab that is an odd quarter-wavelength thick. A millimeter-wave image is thus focused on the front of the slab, which in its normal state has low conductivity and reflects little of the incident radiation.

On the back of the slab is a metal

Imaging system designed to see through fog or smoke is in early stages of development at Fort Monmouth, N.J. Scanning light source enhances reflectivity of germanium to millimeter waves at the point it strikes. Synchronization of light source scan with CRT scan produces visual image of scene illuminated by millimeter laser.


MILLIMETER LASER SOURCE
RADIATION DIRECTED INTO FOG OR SMOKE
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MILLIMETER RADIATION DETECTOR
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SCAN DRIVE
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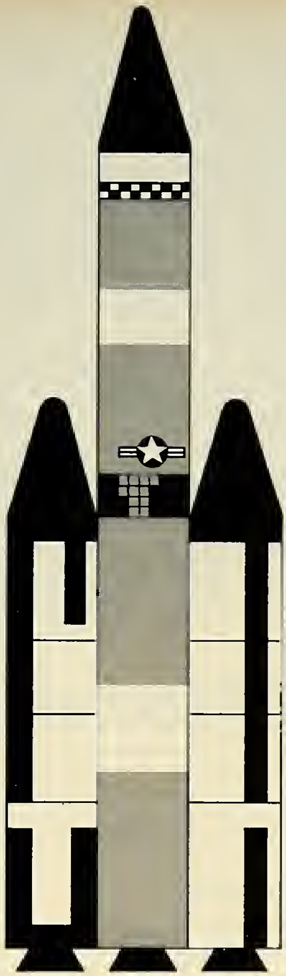

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or wire mesh through which a light beam can penetrate. In fact, a pencil light beam scans in a raster pattern across the back of the slab.

Where the light beam impinges, the conductivity of the semiconductor is enhanced and the millimeter radiation is reflected. The amount of radiation reflected as the light beam scans across the slab is proportional to the intensity of the millimeter wave image at corresponding points. A horn located in front of the slab collects this reflected radiation and feeds it to a detector, which produces a signal comparable to the video signal in a television receiver.

This signal is then used to intensity modulate a cathode-ray-tube beam in which X and Y scan is synchronized to that of the moving light spot. The result is a visual display of the millimeter-wave image on the slab.

Germanium semiconductor has been used, the metal grid providing a means of tuning its characteristics to the point at which the light spot enhances the reflection to the maximum degree. With a microscope light as the source, the conductivity has been enhanced by a factor of about five to yield a 25-35% change in reflected power, which is about 10^{-4} of the incident power.

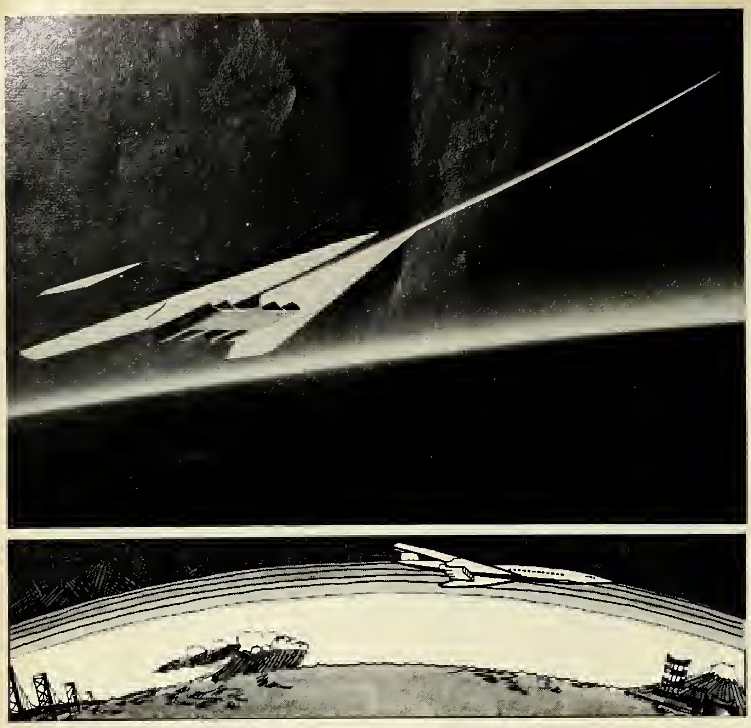
A rotating mirror system is used to produce the scanning motion of the light spot. The frame rate is limited by the lifetime of excess carriers generated by the light spot, which has been measured as 50-100 microsec.

The optimum spot size for a given resolution in the millimeter-wave image has not been evaluated yet. The light spot can be considerably smaller than the smallest millimeter spot, but at the cost of a reduction in sensitivity.

Alternates rejected—Jacobs said that improvements in system performance were hoped for in plans to operate the system at higher frequencies, but further circuit development is required before this can be done. A diode mixer has been used as the millimeter-wave detector, operating at room temperature.

Jacobs said that alternative imaging systems had been considered and rejected on the grounds of complexity or performance. A millimeter radar system works well but requires a truckload of equipment, he commented. It would also be possible to use a mechanical horn to scan the incoming radiation, but this system produces noise from the moving joints and cannot image moving objects. An electron beam could be used instead of a light beam, but this would bring in unnecessary complexity.

He believes the system under development is the simplest and the most suitable for vehicle or aircraft use and that it has very great potential. He is anxious to determine its capabilities in the sub-millimeter region. ■



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Soviets Predict Spaceflight Maturation

by Heather M. David

Las Vegas, Nev.—Manned spaceflight has passed the "kindergarten" stage and it is time to consider a more serious kind of activity with more complex vehicles in Earth orbit, two Soviet scientists have said.

Speaking at the 37th annual scientific meeting of the Aerospace Medical Association here, Dr. Armen Aramovich Gyurdzhian and Ivan Andreyevich Filekin indicated their personal opinion that the emphasis of manned spaceflight will be on orbital space stations before a trip is made to the Moon.

The Russians also said that Soviet animal experiments in space have entered a new series in which they are looking for re-adaption or readjustment in space flights. They also predicted that they would see manned planetary missions in their lifetimes.

Though the scientists stressed they were not representing official Soviet policy, they indicated that the Russians are deeply interested in a long-duration orbital space station. Filekin, a mechanical engineer who works with cosmonaut training devices, told a press conference that it was now time to think of activities in orbit such as assembly of different structures and launch from orbit.

Gyurdzhian, a medical doctor with the Soviet Academy of Sciences, called a space station an "essential step in the development of space technology, not only for technicians but for space medicine people."

New pressure suit—Other developments outlined at the annual meeting included a new concept for a pressure suit which applies mechanical pressure to the skin by the expansion of air sealed in a series of rubber tubes.

According to Maj. Jefferson C. Davis of the Air Force School of Aerospace Medicine, who reported on the project, the suit would answer some of the complaints about pressure suit wear for extended aircraft.

Emphasis of the new design has been on comfort in the unpressurized state, since the suit would be unpressurized most of the time it would be worn. According to Davis, tests have been conducted to demonstrate adequate emergency protection and mobility to take corrective action in the event of catastrophic loss of cabin pressure.

Suit description—The suit is pressurized through the use of ⅞-in.-dia. tubes inserted into pockets sewn between a non-elastic outer layer and an elastic inner layer. Arm tubes are 30 in. long and contain 60 milliliters of room air at ground level. Lower extremity and torso tubes are 36 in. long and contain 80 milliliters of air at ground level.

Fabrics in the suit are porous, and the garment is loose fitting. The tubes, which run longitudinally along the limbs and horizontally about the torso, are independent so that if one is ruptured, the others are not affected.

According to Davis, a helmet is used to pressurize the head and face, although the helmet is made of soft design and can be worn folded back around the neck.

In the event of cabin depressurization, he said, an aneroid-spring-operated mechanism provides automatic closure of the helmet. A truncated rubber collar provides a pneumatic seal for the helmet at the neck, in a manner similar to existing pressure suits.

For spacecraft use, Davis said, the helmet could be pressurized from a small portable oxygen cylinder and regulator carried in a suit pocket or as a backpack, providing oxygen for 10 to 21 min. during an emergency.

Hand and foot protection has been accomplished with only standard leather flying gloves and boots, Davis said, although sealed tubes could also be constructed into these areas if necessary for spaceflight use.

The new pressure suit concept has been tested in the altitude chamber at Brooks AFB up to 75,000 ft., with further altitude tests suggested for a second model.

The follow-on model, Davis recommended, will require careful attention to fabric selection. The strongest, yet lightweight, porous non-elastic outer material that can be found will be needed, he said, along with an inner layer of a very elastic, yet porous, fabric. Davis suggested a study of rubber technology to find the best material for the sealed tubes, which he also recommended should be constructed with a

WDL To Make Sophisticated Sensors

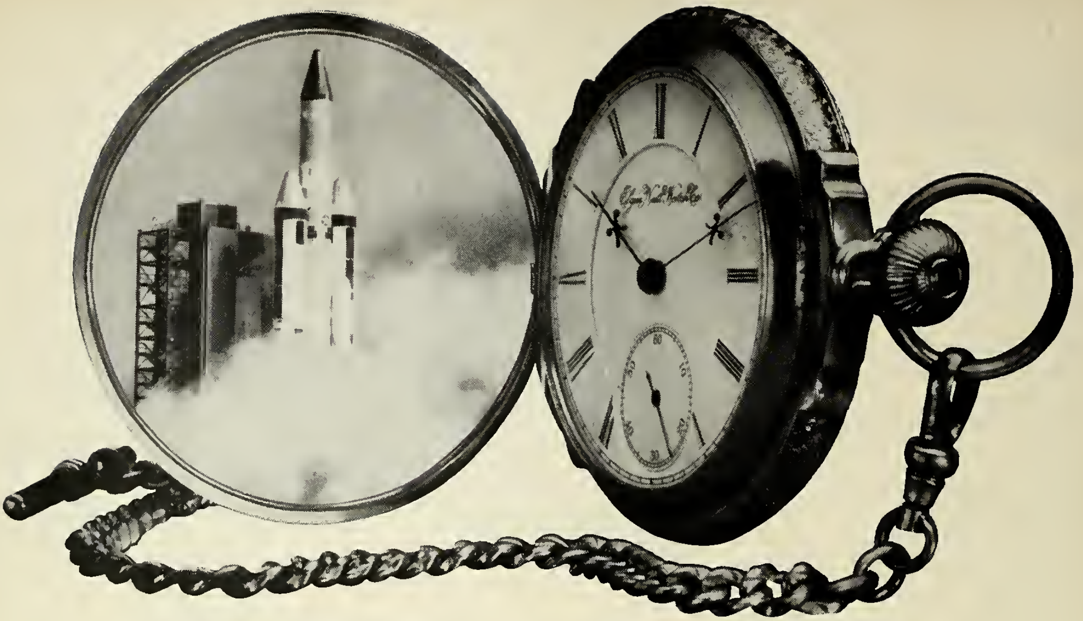
Las Vegas, Nev.—Philco Corp.'s Western Development Laboratories has received a contract from NASA's Electronics Research Center for a new concept in physiological monitoring with unattached sensors.

Philco scientist/engineers M. E. Fitzwater and P. G. Halvorson demonstrated at the Aerospace Medical Association meeting in-house work they have accomplished. The new technique is based on development of sensors which can be incorporated into fabric or put on chairs or other surfaces which might be in contact with the astronaut. The group demonstrated the technique using an office chair.

Electrocardiograph, pulse waveform, heart sound, respiration waveform, galvanic skin response, and electromyograph were among the measurements which could be obtained with the use of the equipment. The sensors in the demonstration were electrodes incorporated into the arms of the chair and a microphone placed in the aortic regions of the back. The measurements, which are attained as soon as the subject sits down, are read out on a single display unit in the form of a conventional graph.

Philco has developed this system to utilize the "noise" from standard signals to give information on additional parameters. Background noise from the EKG, for instance, is displayed separately as myographic or muscle data.

Use of the equipment in space would not only solve the problems of encumbering the astronauts with electrodes and wires but could also minimize the number of information channels needed to relay medical data to the ground. Most of the conventional measurements, the Philco group said, could be combined into three or even two signals, then broken out on the ground. State-of-the-art electronics are used.



Space and time at UTC

Five years ago, United Technology Center dedicated its rocket research, development and production facilities in California. Since then, UTC has developed and produced the world's most powerful operational rocket—the 1,200,000-pound thrust, 120-inch diameter, segmented solid propellant booster. These giant rocket motors have been demonstrated through 14 full-scale static tests, delivered to Cape Kennedy, and flown in pairs as the "Stage Zero" boosters for the Air Force's Titan III-C in three perfect performances.

Time is relative in the space age. UTC provided the people, the facilities, and the management to bring in our mightiest flight-ready propulsion system in the first five years. This team and these facilities now stand ready to take on the next generation of assignments in space age propulsion.

United Technology Center DIVISION OF UNITED AIRCRAFT CORPORATION

Sunnyvale, California

Solid milestones in the first five years at UTC

AUG. 1961: First successful test-firing of a large segmented solid propellant rocket.

MAR. 1962: First successful test-firing of segmented solid propellant rocket using a lightweight fiberglass case and metal joints.

DEC. 1962: Test-firing of single solid propellant rocket composed of 12 segments.

JAN. 1963: First test-firing of a cluster of large segmented solid rockets.

FEB. 1963: First successful test-firing of a one-segment 120-inch diameter rocket.

JULY 1963: Test-firing of one-million-pound thrust, five-segment, 120-inch diameter solid rocket, then the world's largest.

OCT. 1963: Announced development of new fast-burning solid propellant capable of accelerating a rocket to eight times the speed of sound in less than one second.

MAY 1964: Started development of small solid-propellant staging rockets to separate Titan III-C booster from the core vehicle.

DEC. 1964: Shipped to Cape Kennedy the largest solid rockets ever transported by train.

APR. 1965: Completed 28-month ground test phase of 120-inch-diameter motor development program with 14th full-scale static test-firing of a five-segment rocket.

JUN. 1965: Perfect performance in first test flight for a pair of UTC booster rockets developing nearly 2.5 million pounds of thrust at lift-off.

AUG. 1965: Successful flight of high-performance, top-stage solid rocket, increasing polar orbit capability of Scout vehicle by 25%.

UTC ®

valve in one end of the tube so that air volumes can be easily changed to determine ideal volumes in all body areas.

The suit would be adaptable to many users through the insertion of lacings along each extremity and the torso, or individual fitting could be done.

EVA suit—Another new concept in pressure suits was outlined by Lt. G. D. Callin and Lt. Col. W. C. Kaufman of the Aerospace Medical Research Lab at Wright-Patterson AFB. The AMRL scientists reported on studies of the thermal control systems for pressure suits with particular attention to extravehicular use.

AMRL scientists told those attending the meeting that while the thermal transport-system in the *Apollo* suits allows for a maximum continuous removal of 400-500 kcal hr. (1,600-2,000 Btu/hr) of metabolic heat, the heat-removal problems of purely orbital extravehicular activity such as in the *Gemini* or *Manned Orbiting Laboratory* programs might not be as extreme.

It has been suggested, they said, that perhaps only the arms and shoulders might be used to any great extent under zero-gravity conditions. For purposes of the study, they assumed that in orbital activity astronauts would use their legs for bracing only, and that arms and shoulders would be used for heavy work under zero-gravity conditions.

A number of tests were carried out at AMRL to determine a reasonable metabolic activity for a man in a three-hour extravehicular mission, and to incorporate this finding and other physiological factors into a concept for a semi-passive thermal control system.

A theoretical design for a semi-passive system with which to compare data was constructed by the scientists. It consists of a water-cooled suit with water circulating through a reservoir and to a flat plate radiator of 0.5 sq. meter area—about that of the *Apollo* backpack. Total amount of water in the closed system is 10 kg.

The scientists calculated that the temperature of the water would be injected into the system at 5° C and would be allowed to rise to 30° C. A net radiative heat loss of 182 kcal each orbit was calculated, with the additional total of 250 kcal stored by the circulating water for the EVA mission lasting two or three orbits. The total heat removal requirement of 225-350 kcal/hr. probably could be handled adequately by a passive thermal transport system.

Closed system tests—The Air Force also reported the first full results of the 56-day helium-oxygen confinement test at 5 psi (M/R, Dec. 20, p. 38), which was announced earlier by Gen. Bernard L. Schriever, head of the Air Force Systems Command, as being in support of the *MOL* program.

While no final decision has been reached on the *MOL* atmosphere, the physicians and scientists from SAM reported that the test validated the atmosphere for long-term use in manned spaceflights.

The only difficulties reported by the four crewmen in the test were a dryness of the mucous membranes and abdominal cramps caused by gas. These, however, were attributed to a low relative humidity and other factors not associated with the exotic environment.

The findings differed only slightly from those of earlier 100% oxygen atmosphere studies, also at 5 psi, in that the drop in hematocrit noted in the pure oxygen test did not occur in the helium-oxygen version. This was attributed by doctors at the conference to a response to the higher-than-sea-level partial pressure of oxygen in the pure-oxygen environment.

Other blood studies were essentially normal, except for an unexplained rise in two enzymes by one subject. However, this situation returned to normal shortly after it appeared.

A difference in pulmonary function was noted in that it was easier for the crew to move air through the lungs, because of decreased atmospheric density.

Some variations in findings over the thermal comfort index in the helium-oxygen atmosphere were apparent in papers presented at the conference.

Douglas Missiles and Space Systems Div. scientists reported that subjects could endure much higher temperatures —as much as 82° F ±9°—in the helium oxygen atmosphere at 5 psi. If this is true, they pointed out, great savings could be made in weight of blowers and associated cooling equipment.

AF thermal tests—The Air Force reported that it is planning further thermal balance tests at different atmospheres, using classic measurements to determine the actual effect of the temperature on the men's bodies, both at rest and at work.

Douglas engineers and scientists also reported on combustion characteristics of squares of cotton cloth that were tested both on the ground and in zero gravity for burning characteristics.

Initial combustion tests, the group said, indicated that the helium-oxygen mixture required increased power to achieve an ignition point temperature equal to that for the nitrogen-oxygen atmosphere. At a constant input power level, the helium-oxygen atmosphere showed a longer ignition time than the nitrogen-oxygen mixture.

In summary, they said the combustion rate tests revealed that helium-oxygen has a longer ignition time, faster combustion rate and shorter total burning time than the nitrogen-oxygen atmosphere. ■

Air Force Receives Low-Cost, Accurate Navigation System

by **Ronald G. Barnhart**

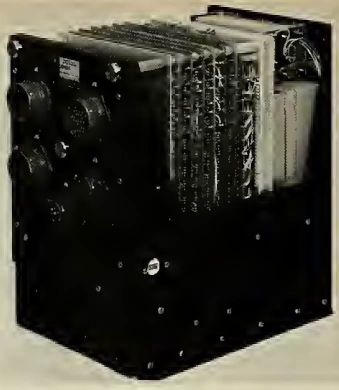
WAYNE, N.J.—After three months of in-plant testing, the Kearfott Systems Div. of General Precision, Inc., has shipped a prototype model of a low-cost inertial (LCI) navigation system to Holloman AFB, N.M., for qualification testing.

The result of seven years of company-funded effort, the Kearfott LCI system is GPI's bid to satisfy a longstanding Air Force requirement for a general-purpose navigation system that will cost under $25,000 in production and still give position readings accurate to within one nautical mile per hour.

Kearfott reports that during its in-house testing here the system performed with an accuracy ranging between 1 and 2 nautical miles per hour. The Air Force will now put the system through extensive bench tests at Holloman, followed by flight tests in C-130 and F-106 aircraft. A Kearfott spokesman said that these tests should be completed by mid-summer.

In addition to use aboard fixed-winged aircraft, helicopters, and VTOL aircraft, Kearfoot foresees LCI systems being utilized in missiles, particularly in air-launched tactical missiles. The division is proposing a version of its LCI system to Boeing and Martin for the *SRAM* program.

Two elements—The Kearfott LCI system consists of two basic subsystems: a miniature gyro platform which incorporates all necessary electronics in plug-in microelectronic modules, and a special-purpose digital computer, which also makes extensive use of microelectronics. In flight models, system power will be provided from aircraft supplies or by self-contained batteries.



Dynamic Differential Analyzer used in LCI has been trademarked "DYDAN."

Kearfott reports that its ultimate objective is to design an LCI system that will weigh under 20 lbs. and occupy less than 600 cu. in. of space, excluding power supply.

The platform portion of Kearfott's prototype system is designed around a company-developed low-cost gyro plus a miniaturized version of a standard Kearfott two-axis, force-balance accelerometer. In future systems, the platform will be available in both 3- and 4-gimbal models. The other major subsystem, the computer, is said to be as accurate as most general-purpose digital computers. It features a 6,000-bit memory, a 1-megacycle clock frequency, a numerical readout and built-in self-test circuits.

Eventually, Kearfott believes, the system can be refined to provide a navigational accuracy better than the 1-nautical-mile-per-hour requirement, with a true-heading error of less than 0.1 degree. Some of the critical components of the LCI system are being applied to a gyrocompassing attitude reference (GAR) system now being built by Kearfott for the U.S. Navy. The first version of the GAR system will be delivered to the Navy for testing this summer, Kearfott reports.

Competition—Other aerospace companies are also actively engaged in LCI systems design, including Teledyne Corp., North American Aviation's Autonetics Div., Northrop Nortronics, Litton Industries, and A.C. Electronics Div. of General Motors. Like GPI's Kearfott System Div., these firms are developing prototype LCI hardware on company funds for Air Force testing. After Holloman evaluation of all prototype systems, it is anticipated that a full-blown development contract—and eventually a production contract—will be let.

General Precision's Aerospace Group includes, in addition to Kearfott Systems Div., Kearfott Products Div., GPL Div. and Aerospace Research Center, with headquarters in Little Falls, N.J. ■

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Nuclear Power for European Comsats Furthered by Study

GENEVA—Joint development work on a nuclear power unit for European communications satellites has been given a further boost following an 18-month study of European potential and projected requirements.

The European Nuclear Energy Agency (ENEA), which has been responsible for initial work in the undertaking, has asked the European Conference on Satellite Communications (known as CETS for Conférence Européene des Télécommunications par Satellite) to participate in future development work.

The organizational interface between the two agencies is now being defined. Efforts to provide up to 100 watts of nuclear power for either navigation or communication satellites are now at the program-definition phase. Proposals are being evaluated on estimated costs, financing methods, organizational setup of detailed research, and other aspects.

Most likely candidates for nuclear sources are actinium 227, polonium 210 and plutonium 238. The Ac 227 and Po 210 sources are most promising from the standpoint of European production.

After the 18-month study by ENEA experts, it has been recommended that the development of nuclear power units based on radioisotopes be continued on an international rather than national level. The recommendation presumably implies international within Europe, and under ENEA auspices.

Probable division of responsibility in the nuclear power program will be along technology lines, with ENEA handling the radioactive source portion of the system and CETS the conversion equipment, since the latter is considered in the realm of space technology rather than nuclear energy.

Communication satellites—Since the beginning of this year, CETS has met with officials of the European Space Research Organization (ESRO) and the European Launcher Development Organization (ELDO) in an effort to get an agreement ironed out on communications satellite development. A satellite must exist before it can use nuclear power, and this is a point currently under intensive negotiation.

As of now, the ELDO vehicles *F-9* and *F-10* are slated to put experimental communications satellites into orbit. These are designed merely to iron out the system, gain experience and set the stage for later operational satellites.

There is not yet a firm arrangement, however, as to who will do what on the program. CETS is the cognizant agency for the work, but either ESRO or ELDO will handle the development phases. The situation is somewhat analogous to NASA putting satellites into space for the Environmental Science Services Administration.

European observers feel that ESRO is the logical and likely partner of CETS in the program, but that considerable negotiating, decision-making, and financing details still require attention. There has not yet been a decision even on the makeup of the managerial and developmental agencies, however, and ELDO could conceivably become the development manager if ELDO survives its present struggle to stay alive.

Work is being carried out by CETS in house on a basis of "if and when" the overall program is approved by all the governments involved.

Blue Streak, ELDO first stage, is shown in successful launch at Woomera, Australia.

CETS soul searching—CETS is in the midst of an era of decision-making concerning the European communication satellite program, including the *F-9* and *F-10* launch planning and specifications, detailed discussions with sister agencies whose activities and support affect CETS decisions, and long-range project planning.

Collation of various national R&D programs beyond the *F-9 and F-10* launches is considered essential, and will clarify future preferences as well as help set the direction of European communication and navigation satellite work.

Included in the future projects under study by CETS is a broadcast television network.

Despite the uncertainty regarding CETS and its working partners, particularly ELDO, the *F-9* and *F-10* launches of experimental communications satellites will be carried out exclusively under ELDO supervision.

Work remaining to be done includes agreement between CETS and ELDO on specifications for the final stage, firming up specifications for the payload itself, systems studies for joint European operation, study of similar work carried out in the U.S. and USSR, and liaison with Eurospace for reliability and fundamental technology considerations.

Eurospace is the association of private European companies engaged in space work.

Auxuliary payloads—Orbiting of any secondary payloads by the *F-9* and *F-10* vehicles in addition to their communication satellite payloads has been held out as a possibility, but ELDO has declined to accept any financial responsibility for such packages. Any costs involving auxiliary payloads, says the launcher organization, must be borne directly by the countries involved.

In order for such secondary payloads to be included on a space-available basis, it would be necessary for ELDO to sign separate agreements with each interested nation. Responsibility for accepting or rejecting a given experimental payload lies solely with ELDO.

Figuring heavily in European planning for a communication satellite system is the U.S. *Apollo* program and its ultimate effect on a world system, and the plans being made by the U.S.'s Comsat Corp. through 1975.

In all the discussions between various European organizations affected by the possibility of a communication satellite program, speed of implementation has been stressed because of the time scale differences between the U.S. and Europe. ■

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New Activities

Honeywell, Inc., Minneapolis, has set up a new department to consolidate the firm's communications activities. The department, located at Honeywell's aeronautical facility in St. Petersburg, Fla., will research, develop and produce communications systems and devices for a variety of military applications. Most of the communications work previously conducted at military plants in St. Petersburg, Tampa, Fla., West Covina, Calif., and Seattle, will now be centered in St. Petersburg. . . . *Bird Electronic Corp., Cleveland, has established an Export Div. under the direction of J. Zurga. The firm manufactures instruments for RF power measurement.* . . . North American Aviation. Inc., El Segundo, Calif., has renamed its invention marketing subsidiary Navan, Inc. The firm was formerly known as Navan Products, Inc.

Mergers and Acquisitions

Litton Industries, Inc., Beverly Hills, Calif., and Diebold, Inc., Canton, Ohio, have announced a preliminary agreement to merge Diebold in Litton for an exchange of stock valued at more than $96.7 million. Under tentative plans, each share of Diebold common stock will be exchanged for 0.43 share of Litton convertible preference stock. The plan is subject to approval of Diebold stockholders and directors of both firms. . . . *Disc Pack Corp., Hawthorne, Calif., has become an affiliate of Memorex Corp., Santa Clara, Calif. According to Laurence L. Spitters, Memorex president, the firm anticipates acquisition of Disc Pack later this year. Disc Pack designs and develops memory discs for computers. Memorex manufactures precision magnetic tape.* . . . Elpac, Inc., Newport Beach, Calif., has purchased all assets of Hast Associates, Buena Park, Calif., manufacturer of microwave stripline components and systems. . . . *Fansteel Metallurgical Corp., North Chicago, Ill., has acquired the assets of High Density Corp., Cleveland. High Density produces ferrous and non-ferrous parts from metal powder.* . . . The Stanley Works, New Britain, Conn., has purchased the assets of Volkert Stampings, Inc., Queens Village, N.Y., for approximately $10 million. Volkert produces precision stampings for the electronics industry.

International

TRW Inc.'s Electronic Components Div., Des Plaines, Ill., plans to build a $2.5-million electronic manufacturing facility near Taipei, Republic of China. Construction of the plant is expected to begin within the next few weeks. The operation will be a wholly owned subsidiary of TRW, Inc. . . . *Beckman Instruments, Inc., Fullerton, Calif., has established a new subsidiary in Mexico City. The firm is called Beckman Instruments de Mexico, S.A. de C.V. Merle B. Hayes has been named general manager of the plant.* . . . Motorola, Inc.'s Military Electronics Div. has named two new foreign distributors. Cannon Electric Pty. Ltd., Melbourne, Australia, and Marubun Co., Ltd., Tokyo, Japan, will market the division's complete line of products in Australia and Japan.

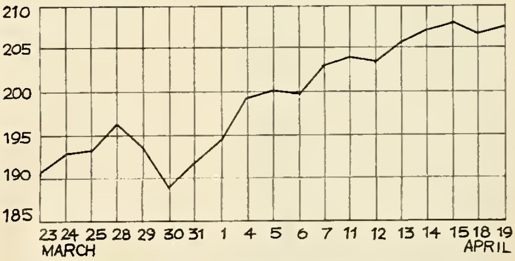
Fairchild, Raytheon Settle Patent Dispute

Fairchild Camera & Instrument Corp. and Raytheon Co. have signed a cross-licensing agreement involving semiconductor patents. Patent litigation previously brought by Raytheon against Fairchild has been dropped. Under terms of the agreement, Fairchild granted Raytheon a license for patents connected with manufacture, use and sale of semiconductor products. Fairchild is also cross-licensed under Raytheon's semiconductor patents.

Industry Facilities

Lockheed-California Co., Burbank, Calif., is building a 5,000-sq.-ft. acoustics test facility at the firm's Rye Canyon Research Laboratory. Research will concern noise control techniques, effects on materials and structures and other aerospace applications. . . . *Douglas Aircraft Co.'s new Advanced Research Laboratory was dedicated April 5 in Huntington Beach, Calif. The facility is designed to broaden the firm's scientific capabilities in areas basic to its space, missile and aircraft programs.* . . . Aerojet-General Corp. has put into operation a new acoustic test facility for research and development of advanced transducers. The facility is located at the firm's Von Karman Center, Azusa, Calif. It will be used to strengthen Aerojet's Oceanic Products Div. . . . *Atlantic Research Corp., Alexandria, Va., has opened its new Ordnance Div., in the Shirley Industrial Park, Springfield, Va.* . . . IIT Research Institute, Chicago, has dedicated a new $10-million research building. Facilities are devoted primarily to research in physics, electronics, geophysics, computer sciences and astrosciences. The 20-story building increases the institute's building space by two-thirds. It is designed to provide space for expansion needs through 1970. IITRI is a not-for-profit contract research affiliate of the Illinois Institute of Technology.

Missile/Space Stock Index



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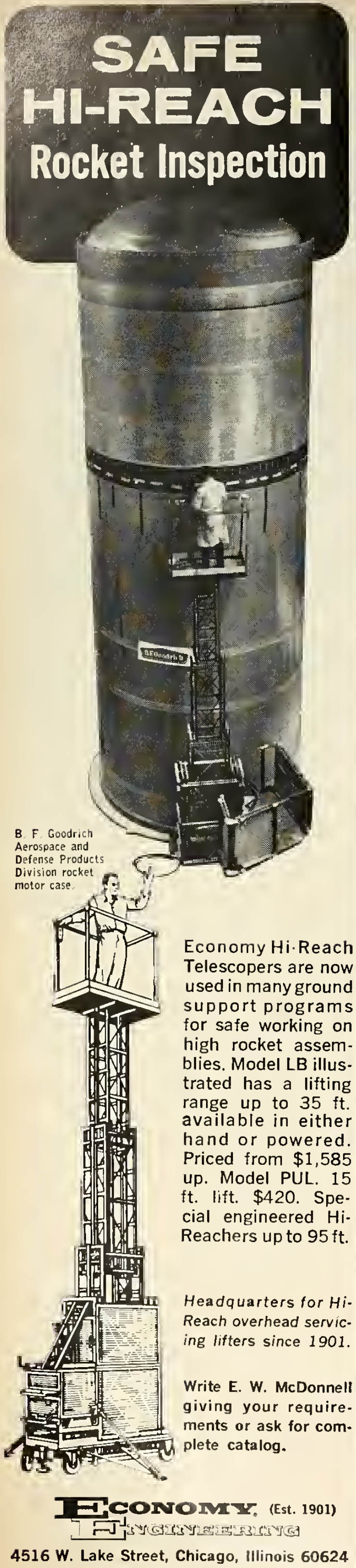

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Contracts and Procurements

AWARDS

AIR FORCE

$5,505,000—**Lockheed Aircraft Corp.,** Lockheed Missiles and Space Co., Sunnyvale, Calif., increment to existing contract for work on the *Gemini* program target vehicle system.

$1,200,000—**Bendix Corp.,** Radio Div., Baltimore, for airborne navigation and weather radar systems.

$200,000—**Aerojet-General Corp.,** Von Karman Center, Azusa, Calif., for combustion evaluation of a light-metal hydride-gelled fuel with selected oxidizers.

$100,000—**Douglas Aircraft Co., Inc.,** Missile and Space Systems Div., Santa Monica, Calif., for experimental evaluation of expanded pyrolytic graphite for use in space radiators.

$92,901—**North American Aviation, Inc.,** Rocketdyne Div., Canoga Park, Calif., for designer's guide and computer program for ablative materials in liquid-rocket thrust chambers.

$83,388—**Goodyear Aerospace Corp.,** Akron, Ohio, for design, development and fabrication of *Arcas* and *Judi-Dart* meteorological rockets.

$75,000—**Stanford Research Institute,** Menlo Park, Calif., for ballistic missile defense radar countermeasures research.

$55,300—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for research on re-entry ECM investigation.

ARMY

$17,890,854—**Raytheon Co.,** Andover and Waltham, Mass., in two contracts for guidance systems and ground support plus field maintenance equipment for the *Hawk* missile system.

$2,900,000—**Sylvania Electric Products, Inc.,** Mountain View, Calif., for R&D in the electronic warfare field.

$1,689,466—**Philco Corp.,** Newport Beach, Calif., for engineering services for the *Chaparral* air defense system.

$384,352—**Honeywell, Inc.,** West Covina, Calif., for *Redeye* guided-missile weapon-system intercept aerial trainer and accessories.

$170,278—**General Applied Science Laboratories,** Westbury, N.Y., for a nine-month research study pertaining to supersonic-combustion ramjet development program.

$43,500—**Ryan Aeronautical Co.,** San Diego, Calif., for advanced satellite tracking instrumentation study.

$40,000—**Philco Corp.,** Newport Beach, Calif., for *Shillelagh* missile system RDT&E program.

NAVY

$3,451,949—**Universal Match Corp.,** St. Louis, for continued work on shipboard missile-launching equipment.

$297,775—**American Cyanamid Co.,** Stamford, Conn., for R&D of oxidizers and binders for use in rocket propellants.

$233,200—**North American Aviation, Inc.,** Autonetics Div., Anaheim, Calif., for R&D program on a multi-frequency radar missile-seeker.

$125,000—**Martin Co.,** Orlando, Fla., for R&D on a charged-particle accelerometer for period of 12 months.

$99,573—**Bendix Corp.,** Bendix Radio Div., Towson, Md., for R&D on a technique for surface target identification for missile applications.

$97,819—**Eastern Research Group,** New York City, for studies directed toward advanced ducted propulsive devices for torpedoes.

$77,710—**Clevite Corp.,** Cleveland, for R&D on advanced rocket nozzles and associated structures for high-performance propulsion systems.

$49,645—**Stanford Research Institute,** Menlo Park, Calif., for research and exploratory development program to define the areas of research needed for missile guidance in the 1970-1975 era.

$24,927—**ARA, Inc.,** West Covina, Calif., for R&D program to establish the feasibility of using nuclear quadrupole resonance techniques to non-destructively test the properties of nonmetallic materials and structures.

NASA

$928,738—**General Precision, Inc.,** Link Group, Binghamton, N.Y., from Manned Spacecraft Center for maintenance and modification of the MSC simulator complex.

$467,412—**General Motors Corp.,** GM Defense Research Labs., Santa Barbara, Calif., from Marshall Space Flight Center for study of lunar wheel and drive system experimental program (*AES* payload).

$443,087—**Radiation, Inc.,** Radiation Systems Div., Melbourne, Fla., from Manned Spacecraft Center for two PCM acquisition and stored program decommutator systems and one PCM signal simulator.

$241,471—**Teledyne Systems Co.,** Los Angeles, from Flight Research Center for pulse-code-modulated subcommutators.

$232,944—**Honeywell, Inc.,** Systems and Research Div., Minneapolis, from Langley Research Center for analytical and preliminary design study for an Earth-coverage infrared horizon-definition measurement program.

$199,460—**Garrett Corp.,** AiResearch Manufacturing Co., Los Angeles, from Langley Research Center for study for astronaut capabilities to perform extravehicular maintenance and assembly functions in weightless conditions.

$189,500—**Martin Co.,** Baltimore, from Flight Research Center for design and testing of the X-15-2 thermal protection system.

$144,747—**DeHavilland Aircraft of Canada,** Ontario, Canada, from Manned Spacecraft Center for extravehicular crew transfer system.

$141,000—**Lockheed Aircraft Corp.,** Lockheed Missiles and Space Co., Sunnyvale, Calif., from Manned Spacecraft Center for a thermal analysis of the Lunar Excursion Module Propulsion systems.

$82,009—**Douglas Aircraft Co.,** Missiles and Space Systems Div., Santa Monica, Calif., from Langley Research Center for study to determine the dynamic effects of crew motion in MORL.

$71,915—**Ling-Temco-Vought, Inc.,** LTV Research Center, Dallas, from Headquarters for **an** investigation of electron interactions in matter.

$62,516—**Douglas Aircraft Co., Inc.,** Missile and Space Systems Div., Santa Monica, Calif., from Headquarters for establishment of criteria for spacecraft atmosphere selection.

$58,235—**Lockheed Aircraft Corp.,** Huntsville, Ala., from Marshall Space Flight Center for a study of *Saturn IB* debris risk/hazard analysis.

$57,500—**Kaman Aircraft Corp.,** Kaman Instruments, Austin, Tex., from Manned Spacecraft Center for development of instrumentation for measurement of bone densitometry.

$53,000—**North American Aviation, Inc.,** Columbus, Ohio, from Langley Research Center for development of infrared stress instrumentation methodology.

$28,754—**Bendix Corp.,** Bendix Systems Div., Ann Arbor, Mich., from Headquarters for small interplanetary probe experiment spacecraft study.

$28,630—**General Dynamics Corp.,** Convair Div., San Diego, Calif., from Marshall Space Flight Center for response of liquid-fueled space vehicle systems to low-gravity conditions.

INDUSTRY

$20,581,000—**Raytheon Co.,** Lexington, Mass., from the **Bell Telephone Laboratories, Inc.,** New York City, to continue development of the Missile Site Radar (MSR) for the *Nike-X* ballistic missile defense program.

$3,500,000—**Dynamics Corp. of America,** New York City, from **General Dynamics Corp.,** Electronics Div., San Diego, Calif., to design and build three giant shipboard antenna systems which will be used in communicating with the *Apollo* man-to-the-Moon spacecraft from instrumentation ships at sea.

REQUESTS FOR BIDS

U.S. Naval Ordnance Laboratory
White Oak
Silver Spring, Md.

Negotiations are contemplated with Goodyear Aerospace Corp., Akron, Ohio, for study and investigation of an optical sonar signal processing system. For information only; RFP not available.

Nike-X Project Office
U.S. Army Materiel Command
Redstone Arsenal, Ala.

Proposes to solicit a quotation from Sperry Gyroscope Corp., Great Neck, N.Y., for research and development study entitled "Advanced Scanner Studies, Advanced Radiometric Tracking." For information only; RFP not available.

Nike-X Project Office
U.S. Army Materiel Command
Redstone Arsenal, Ala.

Proposes to solicit a quotation from Western Electric Co., Inc., New York City, for additional production deployment planning activities under existing contract DA-01-021-AMC-90025 (Y). For information only; RFP not available.

Headquarters
Ballistic Systems Division
Air Force Systems Command
Norton AFB, Calif. 92409

Proposes to contract with the General Electric Co., Philadelphia, Pa., for Mark 12 R&D re-entry vehicles (as test hardware) for the Mark 12 program. For information only; RFP not available.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Va.

Negotiations will be conducted with the Midwest Research Institute, Kansas City, Mo., for a study of low-pressure applications of the orbitron in accord with the contractor's unsolicited proposal P-751 dated 13 Dec., 1965—RFP L-6970. For information only; RFP not available.

National Aeronautics and Space Administration
Manned Spacecraft Center
Industry Assistance Office/BG2
Houston, Tex. 77058

Manned Spacecraft Center intends to negotiate a contract for the development of a gallium arsenide laser. The program is expected to be of one-year duration and will have as its purpose the production of laser diodes having more desirable characteristics than those now available for application in manned spacecraft communication and tracking systems—RFP BG731-30-6-589P —tentative date of issuance 4/20/66. All requests should be submitted to H. T. Christman, Industry Assistance Officer, Bldg. 100.

National Aeronautics and Space Administration
Manned Spacecraft Center
General Research Procurement Branch
Houston, Tex. 77058

Program to determine the effects of combined ultraviolet and proton radiation on selected thermal-control coating materials. RFP BG721-13-6-596P. Copies of the RFP may be secured from MSC Small Business and Industry Assistance Office, Code BG2.

National Aeronautics and Space Administration
Manned Spacecraft Center
Industry Assistance Branch
Houston, Tex. 77058

Development of a digital thermal-analyzer computer program capability for prediction of spacecraft thermal status updated by attitude trajectory and temperature data received via telemetry from spacecraft at frequent intervals during the *Apollo* mission. Firms interested in proposing should request copies of RFP BG731-39-6-600P from H. T. Christman, Industry Assistance Officer, BG2 Bldg., due date 5/19/66.

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METALLURGICAL ENGINEERS—for work in Advanced Structures and in the manufacturing and development of Fuel Cell Electrode Materials.

ELECTRICAL and ELECTRONIC ENGINEERS—for work in Ignition, Industrial and Turbine Controls, controls in electrical systems associated with Fuel Cell Development, and Servo Controls.

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Dick Knox has been pursuing a productive engineering career at Marquardt since 1959. As Project Engineer on Spacecraft Engine Programs, he has actively participated in the research, development and qualification phases of the versatile 100-lb. thrust auxiliary rocket engines which supply maneuvering power to the Project Apollo Service Module, the Lunar Excursion Module, and the Lunar Orbiter. Today, Marquardt is producing these attitude control engines in quantity.

Dick describes Marquardt as an ideal environment where creative engineers can apply their abilities to a broad range of project assignments, "from paper studies to production." In addition to his project activities on the development of small attitude control rockets, his work has included development and testing of the world's first liquid air cycle engine, orbit calculations studies, ejector ramjet research, ballistic vehicle trajectory studies, rocket thrust augmentation, rocket heat transfer, and studies on detonations with hypergolic fuels.

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Reaction Controls Engineers
Conduct analysis, design, and development of high performance advanced reaction control systems using liquid propellants. Utilizes knowledge of fluid dynamics, aerodynamics, thermodynamics, and combustion processes.

Test Operations Engineers
To plan, direct, set up, and conduct operation of rocket and advanced ramjet propulsion test facilities.

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Products and Processes

New Product of the Week: Document Viewer

A viewing unit for reading reports stored on punched-card-sized sheets of microfilm, each sheet containing 90 pages of information, has been announced by the Information Records Div. of International Business Machines Corp.

The IBM document viewer has a non-glare, wide-angle screen and bright, even illumination of the image throughout the entire screen. Rapid information is selected through positive indexing dials; to find the document on the microfiche one selector dial locates the frame horizontally and the other locates it vertically, the company explained.

There are two models, both available with either 24 or 30 × magnification. Model II can simultaneously display two 8½ x 11-in. adjacent documents or single 11 x 17-in. documents onto a 14 x 22-in. screen for reading. Model I can enlarge and project single 8½ x 11-in. documents onto a 14 x 15-in. screen. Both models can be used to view standard microfiche sizes. More than 200 pages of 8½ x 11-in. information can be stored on one 6 x 8-in. sheet of microfilm.

Circle No. 151 on Subscriber Service Card

Mass Property Measurer

A universal mass properties measuring facility designed to find the center of gravity, product of inertia, and moment of inertia of payloads in the 50 to 4,000-lb. class is being marketed by Miller Research Corp.

The Airdyne Model 861 has accuracies including ±0.005 or better on CG location, dynamic balancing sensitivity of 5.0 oz.-in.^{2} at 100 rpm, 0.2 oz.-in.^{2} at 500 rpm for the product of inertia. Moment of inertia accuracies are ±0.5% or better for all values above two slug-ft.^{2} Weight, if included, comes in within 0.2% of actual.

Payload configuration is not a factor and optional extras listed by the firm include a weighing capability, remotely-controlled rebalancing weights, data print-out as required and computer and Airdyne/computer interface.

Circle No. 152 on Subscriber Service Cord

Porous Lead Structures

Astro-Met Associates has announced the availability of lead in porous form in densities about one third that of the solid metal.

The pores are continuous open cells that provide for the flow of liquids and gases under unusual corrosive of pneumatic applications. Pore sizes range

20
NEW
UHF & SHF
ANTENNAS
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MISSILES AND ROCKETS

TWENTY new antennas will be announced in April. Both flush and blade types will be shown at the NTC 66 Boston. A new UHF blade antenna is shown above at the left, mounted on a 5" dia. rocket section with a current VHF blade to the right.

These antennas will be compatible with the new TM and MDI frequencies and the latest and most hostile environments. Watch for them.

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from 1/32 in. to more than 1/4 in. with openings between pores about half the nominal pore size.

Applications range from special battery plates to acoustical and explosive impact absorption. Development specimens up to 3 lbs. are now available.

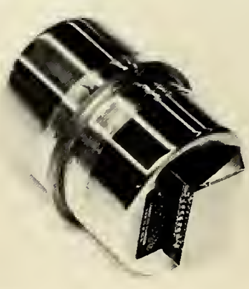
Circle No. 153 on Subscriber Service Card

Two-Axis Gyro

An electrically torqueable two-axis free gyro, designed to function as an inertial reference in such closed-loop applications as antenna platforms and missile control systems, has been introduced by Kearfott Systems Div., General Precision, Inc.

Designed to provide a space stabilization reference for applications in environmental extremes, Model C70 2316 002 features a high angular momentum-to-weight ratio that provides excellent drift stability in a 12-cu.-in. package, the firm says.

A 2-degree gimbal freedom permits use of a momentum wheel larger than its supporting gimbals. Fluid flotation is eliminated through use of ball-bearing suspension. Heaters are not needed, and flex leads are used for power and signal transfer. Low gimbal mass results in minimum aniso-elastic and bearing friction effects under high-g environments. Mass unbalance is less than 0.30°/min/g about each axis throughout all environmental extremes.



Compensated a-c pickoffs and a high-efficiency two-axis d-c torquer complete the basic gyro package, and its momentum wheel is accelerated to running speed within 18 seconds by a rapid-reaction induction-type driven motor.

Circle No. 154 on Subscriber Service Card

Waveform Synthesizer

Exact Electronics, Inc., has announced a solid-state waveform synthesizer said to be capable of simulating an almost unlimited combination of signals.

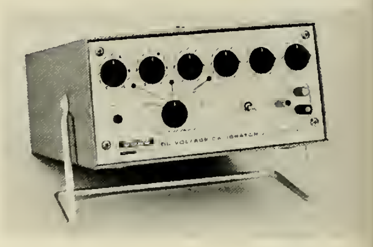
The Type 400 adapts to shock testing and controls current sources through 20 panel-mounted potentiometers. Two independent signals are derived by means of PCB plug-in amplifiers.

Clocking of the unit may be done internally or externally and may be free-run, gated, or triggered to run through a sequence of 10 to 20 increments. Internal clocking is calibrated in steps from 330-millisec. to 100 μsec, with a variable control allowing an increase of the time per increment to four times.

Circle No. 155 on Subscriber Service Card

D-C Voltage Calibrator

A portable d-c voltage calibrator, suitable for applications where a d-c source with output-voltage accuracy within 0.02% at currents up to 25 ma are required, has been introduced by Cohu Electronics, Inc.



Model 325 features output voltage from 0 to ±1111.110v at maximum over-range, which is selected by a range multiplier dial and six-place decade dial group. The range dial has a zero-volt position and full-scale 10v, 100v, and 1,000v positions. Output voltage can be selected in steps as small as 10μv.

The instrument features an isolated output with noise and hum less than 100μv rms. Source resistance is less than 0.001 ohm. Output voltage stability is within 30 ppm for 24 hours and within 50 ppm for 30 days.

Circle No. 156 on Subscriber Service Card

Microhardness Tester

An ultrasonic microhardness tester is being marketed by Branson Instruments, Inc.

The Series B Sonodur instrument provides a direct readout of hardness on standard scales in less than 10 seconds and is accurate to ± 1 point on the Rockwell C scale. Optical measurements and chart conversions have been eliminated.

Depth of penetration of the indenter in RC 65 steel is less than 2.5 microns and 4.5 microns in RC 25 steel with the 150-gram load. The tester can be calibrated to measure most metals by calibrating against two samples of metal.

Primary applications are in testing thin parts and measuring steel.

Circle No. 157 on Subscriber Service Card

Names in the News

SCHLIEMANN

MOQUIN

NEWMAN

ERICKSON

J. B. Schliemann: Elected a vice president of Allied Research Associates, Inc. He was also named general manager of the newly acquired Baltimore Div.

Joseph C. Moquin: Promoted to the presidency of Brown Engineering Co., Inc. He succeeds **Milton K. Cummings,** who will remain chairman of the board.

Robert A. Newman: Named director of public relations and advertising for TRW, Inc. He was formerly a consultant in marketing and public relations services of the General Electric Co.

Andrew J. Erickson: Elected a vice president of Vitro Corp. of America. He is president of Vitro Services Div.

John H. Schuler: Elected president of Anderson Electric Corp. **Thomas H. Fox** was named chairman of the board and **R. E. Schuler,** founder of the company and long-time chairman of the board, was elected honorary chairman.

Walter H. Greenberg: Appointed vice president of engineering and technical director of Riverside Plastics, Bischoff Chemical Corp. He has been responsible for developing many new designs and applications of advanced reinforced plastic parts for the aerospace, aviation, electronic, and industrial fields.

Donald M. Alstadt: Elected executive vice president of Lord Corp. His contribution in basic research resulted in the development of a totally new kind of rubber-metal adhesive.

E. Finley Carter: Elected a director of Applied Technology, Inc. He was formerly president of the Stanford Research Institute and recipient of the Civilian Outstanding Service Medal, awarded in 1963 by the Secretary of the Army.

Arthur F. Woods: Appointed vice president and director of marketing of the Fluid Handling Div. of International Telephone and Telegraph Corp. He was formerly vice president and director of marketing at ITT's Marlow Div.

John M. Wolf: Elected top financial officer of Laboratory For Electronics, Inc. He is former vice president of accounting and controls of Mueller Brass Co.

Alan Cohen: Named executive vice president of Commercial Plastics and Supply Corp. He has been with the company since 1956 and associated with the plastics business for 20 years.

Dr. Antonio R. Rodriguez: Appointed corporate director of research and vice president of Aerovox Corp. He is best known for his pioneering work in the field of ceramic capacitors and holds patents on the Cerafil, Cerol and Ceralam processes as well as for the invention of several piezoelectric and dielectric materials.

Albert E. Keleher: Appointed as vice president of Product Planning, Inc. He will head the firm's activities in the field of cryogenics. He joined the firm in 1963, having served as director of marketing for industrial/defense group of Bulova Watch Co.

T. Roland Berner: Received "The Navy Meritorious Public Service Citation," one of the highest awards conferred on a civilian by the U.S. Navy. He is chairman and president of Curtiss-Wright Corp.

Doyle T. Rickett: Appointed vice president and general manager of the Advanced Circuitry Div. of Litton Industries. He was formerly with Sperry Rand's Univac Div. as manager of units assembly and printed circuit board manufacturing.

Adrian J. Vaksvik: Elected a director of CTS Corp. He is president and resident manager of CTS of Paducah, Inc. He has been with the company for 26 years.

Richard J. Nesbitt: Appointed vice president of operations of Lockheed Shipbuilding and Construction Co. Prior to joining the company, he was vice president and general manager of Gibbes & Cox, Inc.

Joseph L. Mareschi: Named vice president of sales for Walworth Products Div. of Walworth Co. He has been with the company for more than 25 years.

Thomas F. Bergmann: Appointed regional vice president for the Wright Aeronautical Div. of the Curtiss-Wright Corp. Prior to rejoining Wright Aeronautical, he was corporate regional director, southwest Pacific, of Lockheed Aircraft Corp.

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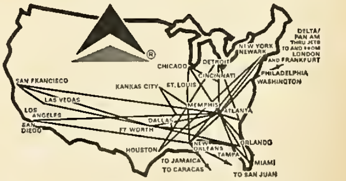

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When and Where

APRIL

Fluids Engineering Conference, sponsored by the American Society of Mechanical Engineers, Cosmopolitan Hotel, Denver, Colo., April 25-28.

National Aeronautic Meeting and Production Forum, sponsored by the Society of Auto Engineers, Statler-Hilton Hotel, New York City, April 25-29.

Spring Section Meeting of the Combustion Institute, Denver Research Institute, Denver, Colo., April 25-26.

Briefing for Industry on the New Naval Material Command, sponsored by the National Security Industrial Association and Navy, Departmental Auditorium, Washington, D.C., April 26.

Region 6 Annual Conference, sponsored by the Institute of Electrical and Electronics Engineers, Pioneer International Hotel, Tuscon, Ariz., April 26-28.

American Power Conference, sponsored by the Illinois Institute of Technology, American Society of Mechanical Engineers, Illinois Institute of Technology, Chicago, April 26-28.

14th Annual National Relay Conference, Oklahoma State University, Stillwater, Okla., April 26-28.

Spring Joint Computer Conference, sponsored by the Institute of Electrical and Electronics Engineers, Boston Civic Center, Boston, April 26-28.

Symposium on Fibers-Morphology and Failure Mechanisms, sponsored by the American Society for Testing and Materials, Textile Research Institute, Princeton, N.J., April 26-27.

Colloquim on Low Temperature, sponsored by Arthur D. Little, Inc., Frankfurt am Main, Germany, April 28-29.

MAY

Electrochemical Society's 129th Meeting, Sheraton-Cleveland Hotel, Cleveland, May 1-6.

Society of Aeronautical Weight Engineers Annual Meeting, San Diego, Calif., May 1-5.

National Transportation Symposium, sponsored by the Institute of Electrical and Electronics Engineers, American Society of Chemical Engineers, American Society of Mechanical Engineers, Jack Tar Hotel, San Francisco, May 1-6.

Canadian Aeronautics & Space Instrument Annual General Meeting, Chateau Laurier, Ottawa, Canada, May 2-3.

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A Sound Review

THE AIR FORCE *ad hoc* committee which reviewed the position of aerospace not-for-profit corporations has turned in a far-sighted report which should do much to clear up a situation confusing from its inception.

The committee is to be congratulated on its willingness to face up to conflicting issues and state genuinely workable solutions. Indeed, the entire approach to the problem of the relationship between the Air Force and its not-for-profit adjuncts has received unusually perceptive handling, from the work of the Hardy subcommittee and the *ad hoc* group through the analytical acceptance of the report by Air Force Systems Commander Gen. Bernard Schriever and Air Force Secretary Harold Brown.

It is rare when a problem as inherently troublesome as the Aerospace Corp. investigation receives such astute attention from people dedicated to finding intelligent answers.

It is gratifying that the *ad hoc* committee so strongly certified the need for the existence of the two major not-for-profit firms under study, Aerospace and Mitre Corp. (Systems Development Corp. presented a different set of problems which the committee wisely dealt with as a separate issue.)

The report states forthrightly: "It is clear that the functions performed by these special organizations are fundamental and represent a long-term and continuing need. It is also clear that these organizations perform these functions effectively and should be strengthened."

That statement, and its unqualified acceptance by Secretary Brown and Gen. Schriever, should remove any doubts as to the future of the two firms, substantially improving morale and the recruitment problem.

By its support of the single-customer concept as opposed to diversification, the committee has wisely cut off the ambitions toward a broader base which perhaps are inevitable in any organization with such talented management—but which in this case are undesirable.

The *ad hoc* group's declaration of confidence in the Board of Trustees of each company, together with Secretary Brown's refusal to bail them out on mortgage financing, should strengthen these groups —thereby putting an end to complaints that management prerogatives were being over-ridden by excessive Air Force interference.

At the same time, insistence that the Air Force have a final say on facilities and a much broader review policy on fees and programs provides protection of the public interest which is not inconsistent with the duties of the corporation.

This is particularly true in regard to in-house research carried out by the corporations. In the past, there has been no effective restriction on the areas of research. Air Force fees, conceivably, could have been used to support medical or product research unrelated to the Air Force effort. The report supports the benefits of in-house research while at the same time insisting it be channeled into fields consistent with the primary mission of the firms.

These research goals are plainly stated:

- The investigation of critical areas requiring technological breakthroughs to provide the next generation of systems.
- The experimental demonstration or simulation of the feasibility of advanced systems.
- The experimental solution of current system engineering problems.

THE REPORT IS EQUALLY CLEAR in its approach to the long-troublesome area of salaries and fringe benefits. There has in the past been an unwillingness by all parties to concede that one of the primary reasons behind the establishment of the not-for-profits was the need to circumvent Government salary scales in order to attract the caliber of engineering talent required.

The committee handles this head-on. The report states:

"Outstanding performance by Mitre and Aerospace requires outstanding people. To require less defeats the whole rationale on which these institutions are based . . . it is to be expected that such a staff requires higher than average salaries."

Acknowledging that many professional scientists and engineers are not willing to become Federal employees, the committee adds: "In its current configuration, the Air Force is faced with manning and grade ceilings which effectively preclude obtaining the required quantity and quality of professional personnel."

This unequivocal approach should do much to lift an albatross from the neck of the not-for-profits which has plagued them from their inception. The salary requirement is a valid one, it is now out in the open, and it is officially approved. This is a major step forward.

The committee does not hesitate, however, to suggest that Aerospace has overdone itself on fringe benefits and wisely calls for a cutback in this area.

Not all of the committee's recommendations were accepted. We agree, for one, with Secretary Brown's refusal to set up a policy group in his office to oversee Aerospace and Mitre. The responsibility rests with Systems Command and that is where he has left it.

All in all, this has been a fine job of work by Congress, the Air Force and the Dept. of Defense. As Dr. Ivan Getting, president of Aerospace Corp., suggests, it will greatly improve the relationship between the Air Force and the not-for-profits. It also clarifies their status with the rest of the industry—a not inconsiderable benefit in itself.

William J. Coughlin

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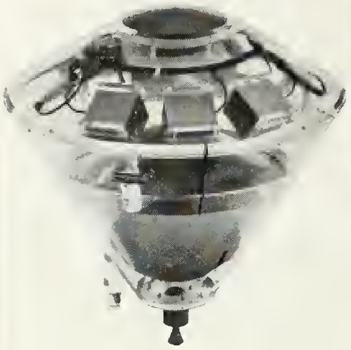
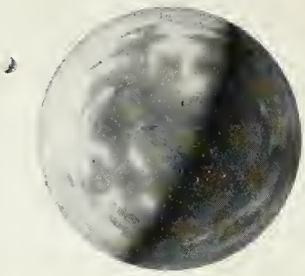


Will man's next probe of another planet look like this?

It could be. This design has more experience built into it than any other now on the boards.



Our planetary neighbors are getting closer and closer.

Soon, more probes will be made, leading up to actual lander vehicles. But, the question remains, what kind of probes?

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